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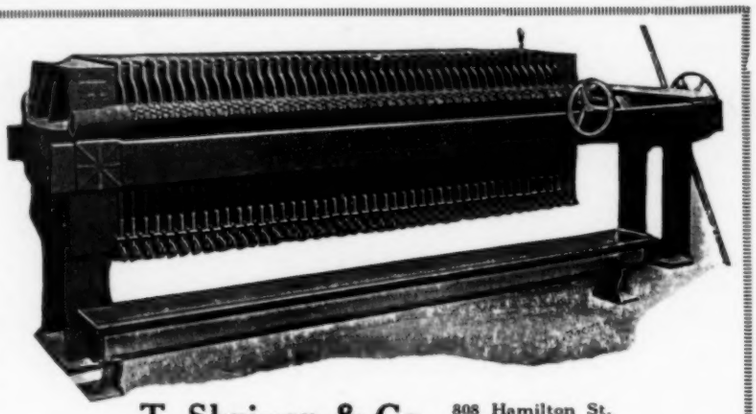

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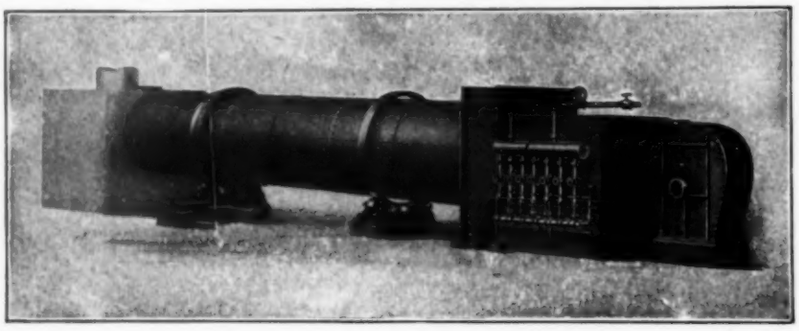

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The Season of Tariff Hearings

ELSEWHERE in this issue we report some of the hearings recently held in Washington before the Ways and Means Committee of the House of Representatives on bills designed to derive revenue for the Government and encourage the domestic producton of certain minerals and mineral products. In other words, a new tariff is about to be framed, and proponents of tariff protection for certain industries have been active in presenting their claims. Tungsten, magnesite, potash, zinc, dyes, optical glass, chemical glass and laboratory apparatus are among the items for which protective duties are asked. The reasons are various, ranging from the protection of key industries to the loyal support of domestic enterprises that will free us from German domination. In the main they are all good.

A reading of the arguments is suggestive of the delicate problems that Congress will be called upon to solve. Shall we protect one industry when the effect will be to levy tribute on several others that would thrive better under free trade? On the one hand we have the infant industry, in this case possibly a war industry, clamoring for protection and urging deliverance from foreign, possibly German, bondage. On the other hand, we find consumers who prefer a foreign product for real or fancied superiority and who object to being taxed to support a domestic industry. Truly the wisdom of a Solomon is demanded. For our own part we have previously expressed an opinion to the effect that industries asking tariff protection must be on a sound economic basis, with good business direction and technical control. We cannot look with favor on substituting a tariff for industrial inferiority or lack of technical skill; nor, on the other hand, do we believe that a little foreign competition will be harmful. In this respect we like the attitude of the tungsten producers, who say frankly that the duty they ask will still permit foreign ore to enter to the extent of half our domestic needs, while it will also act as a stabilizer of the industry at home.

In the case of scientific glassware and apparatus we confess to an abhorrence of the duty-free favor granted our colleges and universities, because it has made German products better known than American; and for the further reason that continuance of the plan affords an entering wedge for German propaganda among our students. On only two occasions, after the Mexican and Civil wars, have our revenue requirements been such as to make it necessary to exact duty from the beggarly funds of our colleges. Today the question is quite different. Freight charges on this class of material are small compared to values. Eighty to 90 per cent of the cost of production is for labor, and the low-wage countries will find these industries peculiarly their own. In Germany there are over 500 firms manufacturing scientific apparatus, employing thousands of instrument makers and technical men. Less than one-tenth this number is credited to the United States even after four years of favorable development. We cannot look with favor on the subordination of these industries at home merely to favor the colleges. We believe our educational institutions want to stand on their own feet and pay their way. We believe that students and faculty alike will scorn the savings that might be effected by taking the sop thrown by foreign competitors. Sixty per cent duty may be needed, and domestic goods may cost our colleges $2,000,000 additional each year, but this may be regarded as insurance against pitiful dependence on an undesirable neighbor.

A New Philosophy Of Chemistry and Matter

ELSEWHERE we print in this issue Mr. HENDRICK'S paper on the Langmuir postulates, which is designed as an introduction to the subject and not as a complete exposition of it. The changes proposed in regard to the conception of molecules and valence are so radically different from those with which we are familiar that it is hard to forego the natural disposition to oppose them. It requires an easy familiarity to make use of the postulates in thinking of chemical reactions and the resultant bodies, and we believe that in time it will be possible to approach them with greater clarity than at present. The series which we present contains but eight, whereas in Dr. LANGMUIR'S original paper there were eleven. In his later papers they will appear in the present form—for which we are indebted to him—and we hope that this, too, will be simplified as time goes on.

The promise, as indicated in the amazing similarities of physical qualities between bodies apparently unrelated except that they are held to be identical in their atomic or molecular structures, is too great to be passed over without careful observation and scrutiny. If by applying the octet rule and determining the covalence of each atom we may determine the physical nature of a body even before it is synthesized, we have, without doubt, an instrument of great value in chemical practice. But it may even be determined, according to Dr. LANGMUIR'S theories, whether unknown substances will have color or not. Again, it has always wrenched us to consider that, among metallic salts, for instance, no molecules are formed, but that they build a lattice of alternate positive and negative ions which are held together by electrostatic force rather than by bonds. Nevertheless this conclusion, which is wholly in accord

with the work of the BRAGGS, now appears reasonable, except in the shade of prejudice; and in the end we seem to obtain from it a remarkably practical working concept of chemical processes. It is, however, unfamiliar—and it is a normal human reaction to deny that which is unfamiliar.

Our colleague the ever urbane editor of *Scientific Monthly* evidently feels that way. After listening to a presentation of the subject by its author during the Convocation Week of the American Association for the Advancement of Science, in Washington, he says, referring to the addresses of Professor BREASTED of Chicago and DR. LANGMUIR of Schenectady, that they (the addresses) "might lead to the inquiry why a student of Mexican archæology is eligible to membership in the [National] Academy but not a student of Egyptian archæology," and "why a metaphysician who calls himself a chemist is eligible, but not one who calls himself a student of philosophy."

As the author of our paper intimates, Dr. LANGMUIR is almost resentful of metaphysics in connection with comprehensible and concrete facts. He does deduce the rule that electrons tend to gather in pairs and octets about positive charges, but if this be metaphysics then so is valence, and so also is the law of definite proportions.

WERNER'S theory of secondary valence, while not wholly in accord with the Langmuir postulates, is illuminated by the octet rule. WERNER'S observations are confirmed, but they are explained by a different method. Neither this feature, however, nor several others of marked importance, are touched upon in our present article. Our immediate business is of an introductory nature.

Are We Engineers or Are We Economists?

A SPECTACLE of high wages together with a surplus of labor, high commodity prices together with a small turnover, extreme spread between wholesale and retail prices and yet moderate purchasing by the ultimate consumer, cold storage and granaries bursting with foodstuffs yet meat and dairy products beyond the reach of ordinary purses—this spectacle certainly holds puzzling inconsistencies to the thoughtful observer. The times are so badly out of joint that his personal experience cannot bridge the gap, and yet he is confronted with the insistent question: "What can I do about it?"

What is to be done? Economists who hold the front of the stage assure us that nothing can be done except grin and bear it; make up your mind to buy what you need and pay the price, say they. "Opportunity is here!" shouts the publicist. "The shelves of the world are bare." True, indeed, but has poor Mother HUBBARD a bare purse as well as a hungry dog?

Students of economic life make much of the so-called law of supply and demand, and its many adaptations. Thus—we have recently seen an enormous inflation in currency and credit, the actual amount of usable goods has probably decreased, prices therefore have gone up with the volume of money available. This really seems a good definition of high prices rather than an explanation of how they came about—in other words, the fact that we have a huge gold reserve is not the immediate reason an Oregon horticulturist asks and gets 13 cents for prunes he gladly sold for 5 a few short years ago. On the face of it there seems to be a human as well as a material element in prices. We are inclined to think—not being economists, merely engineers—that some influential economists have overlooked a profound determining factor in price levels, and this factor is that a price is determined not only by the available supply of needed goods and the total amount of purchasing power in existence, but also in large measure by how badly the individual purchaser thinks he needs and desires the thing, the availability of acceptable substitutes, and the credit or money he actually possesses. When butter goes beyond a certain price, he doesn't buy as much as he needs.

Thus one arrives at the psychological factor, at once ignored and acknowledged by publicists—ignored in arguing for permanence of high prices; acknowledged in their campaign to create a "purchasing state-of-mind." Some even go so far as to print in black headlines "All Price Revisions Will Be Upward!" As a general, long-time trend, yes; as an immediate tendency, by no means! Do they mean that the glaring inefficiency of management, labor and process which was so shamelessly condoned during war time cannot be improved? Do they mean that the exorbitant capital profits, amounting in many cases to the total pre-war cost of the commodity, cannot be eliminated? Do they mean that $12 shall be maintained as a price for a shoe costing $6 simply because the raw material, manufacture and sale are so closely controlled that the higher price can be demanded?

Historical economists are fond of pointing out the rise in commodities which accompanied and immediately followed the four recent wars in justification of their stand that the present price levels will be permanent. Perhaps the analogy is correct. But they fail to add a note explaining the drop in commodities which actually occurred sooner or later. Apparently if it be true that high prices are due to inflation, and inflation is due to the waste of war, it certainly follows that high prices can be cut by reducing waste. Here, indeed, is where the engineer can help—at least he can be of vital force instead of an apologist. The human element is again overlooked when no mention is made of the reason—cited solely as an instance—why pig iron should drop from $53 just after the Franco-Prussian war to $9 just before the Spanish-American war. That was technology! Not only bigger blast-furnaces, but better chemistry and metallurgy, better transportation, better electrical and mechanical engineering, and the application of iron and steel to thousands of everyday uses!

Enough has been said to indicate the extreme complexity of the economic situation. Economic laws are not deducible to mathematical formulæ as are those of gravitation, because the human element—that most complex of variables—enters. Engineers are treading on *terra incognita* and are in danger of being bogged when they make pronouncements based on economics; far better it would be to insist at all times and places upon the extreme desirability of reducing costs by scientific technological management. Here we can speak with authority, candidly acknowledging in all our dealings the close relationship between the human and the material, the worker and the machine.

Reduce waste, perfect processes, increase efficiency of men and machines, lower costs by increasing the volume of production, raise the standard of living by making it possible for the common citizen to purchase good products, and engineers can then rest assured that

their work has been well done, since it has vastly increased the sum total of human happiness. That is really the end of it all!

A Phase of the Flotation Decision

IN OUR digest of the Supreme Court's decision in the case of Minerals Separation vs. Butte & Superior, we doubt if we emphasized sufficiently those words of the Court's opinion in which it defines the scope of Minerals Separation's right as "limited to the means they have devised and described as constituting the process." Granting the plaintiff its right to the process when oil is used in a fraction of one per cent on the ore, the Court nevertheless holds that the patentees discovered the *process* and not the *result*, and limits the process to the *means* disclosed. Evidently if the same result can be attained by some other means, the industry still has the prospect of working with an economical use of oil. In our judgment the bubble-column process, commonly spoken of as the pneumatic-cell process, is outside the means disclosed by Minerals Separation in patent 835,120 and is therefore open to use with an economical quantity of oil, and without infringement of the patent referred to. This may have a profound influence on future flotation practice.

The Determination Of Steel Prices

THE steel market has for many years presented an interesting psychological study. There has been some evidence of the working of the much mentioned law of supply and demand, but after all the steel market has been made more by psychological than by physical influences. It has been a matter not only of how the minds of producers react to certain influences but also of how the minds of buyers react.

In most of the steel price advancing movements of the past fifteen years the co-operation of buyers has been necessary. It was a case of one advance bringing on another. The buyer, seeing the market exhibiting strength by advancing, would place contracts for forward delivery for additional tonnages and when this buying had encouraged the mills to make another advance the buyer would buy again, thus furnishing the basis whereby prices could be advanced upon him a third time, and so on.

As to the sellers, the mental attitude has influenced conduct, though not always in the same way. In the decade of the 1890's, when the mild-steel business was young as the successor to the wrought-iron business, the mental attitude of the producer was frequently not so much that of endeavoring to secure orders as of preventing his competitor from securing them. It was a common practice to induce a consumer to place a contract for material he did not expect to need, with the idea that he might possibly find occasion to use the material, and then the seller who had seen him first would receive the specifications. The fundamental principle was that of undermining the competitor's business rather than of building up one's own business. The pools and associations that throve on paper were patronized by producers not so much because they individually expected to adhere to the agreements as because hopes were entertained that others would do so, and thus lose orders.

Subsequently the psychology of producers changed. Passing over a few years, first of the existence of the combinations preceding the Steel Corporation and then the earliest years of the Steel Corporation itself, there began a period in which the idea of domination was definitely and actively renounced. The larger of the individual manufacturers in the early years of steel-making sought domination as the only safe position. The Steel Corporation, on the contrary, recognized that in the long run domination would be suicidal because neither the law nor the public would give it countenance. Markets, however, must be made through the operation of one influence or another. They do not spring from nothing. Markets are made by men, and the question is only as to the influences to which men allow their minds to react. The influence may be the relation between the tonnage that is likely to be consumed and the tonnage that can be produced, or the mental attitude of buyers, or the mental attitude the producer believes his competitors occupy.

The Great War sent steel prices to undreamed-of levels, and then Government control intervened. At the close of the war demand dropped to small proportions. Here was an upheaval or succession of upheavals which one would naturally expect to leave the market in a highly unsettled state, capable of wide fluctuations. A practical question is whether, after so great a disturbance, steel prices are going to fluctuate more or less during the next half dozen years than they did in the decade before the war. After such a disturbance wider fluctuations than usual might reasonably be expected, but having in mind the psychological influences at work one might conclude that the clearly apparent danger of a widely fluctuating market would induce the men who make the markets, irrespective of whether their decisions are individual or collective, to take special pains to prevent such wide fluctuations in prices.

Much has occurred that is suggestive of the possibility that eventually the Federal Government will be largely instrumental in the formulation of steel-market prices. The Federal Trade Commission was organized in March, 1915, and has had more or less to say about steel prices, particularly during the war. The Supreme Court is to decide the Government's dissolution suit against the Steel Corporation, which gives that branch of the Government a vital interest in the subject. It will, in a measure, pass upon the propriety of the steel prices that have obtained during a large part of the Steel Corporation's life, from the viewpoint of the public interest. Last February the Department of Commerce formed the Industrial Board for the purpose of deflating or stabilizing steel prices, and while the Industrial Board had rather an ill-starred and brief career the fact is not modified that there was a desire in Washington that such an organization should exist and function.

Even nearer to the point is the fact that when the organized steel consumers of the Chicago district recently urged that Chicago be established as a separate basing point for steel products, thus reducing the previously universal scope of the Pittsburgh basis, the steel producers proposed that the matter be laid before the Federal Trade Commission. If it is proper that the Commission should decide what prices should obtain in the Chicago district relative to Pittsburgh basis prices, it is no great step for it to have a voice in determining what prices should obtain at Pittsburgh relative to industrial conditions.

Readers' Views and Comments

Fusibility of Ash From Pennsylvania Coals

To the Editor of Chemical & Metallurgical Engineering

SIR: I have read with much interest the paper on "Fusibility of Ash From Pennsylvania Coals," which appeared in your issue of June 15, 1919. Messrs. Selvig and Fieldner make one statement in that paper which I feel should not pass without some comment and qualification. The last paragraph on page 629 reads:

"The ash from the anthracite region of Pennsylvania is very refractory, coming in Class I. The softening temperature in practically every instance is above 3000 deg. F."

Now this statement is true in so far as it covers the ashes of coals tested and reported in the paper by Selvig and Fieldner, but the fact remains that ashes from certain anthracite coals have not been included in the published results. In order that the statement made by the authors may not mislead any one into regarding all anthracite coal ash as highly refractory, it has been thought desirable to submit some data on work done in this laboratory.

In a paper on "Chemistry in Coal Mining," published in the Aug. 19, 1916, issue of *Coal Age*, a table was given showing fusing temperatures and analyses of ashes of coals from different mines. The content of alkalies in the ashes was not determined, and any titanium dioxide was included in the percentage of aluminum oxide. The data are given in Table I.

This table shows that the ash of some anthracite coals fused between 2210 and 2282 deg. F., whereas the ash from other anthracite coals did not fuse at a temperature of 2570 deg. F., this temperature being the highest reached in the tests made at that time.

Later work in which higher temperatures were reached has shown practically the same results. The ashes from Shamokin, Locust Mountain and Hard White Ash coals have, in general, shown high fusing temperatures, mostly above 2600 deg. F. The ashes from Lorberry coals have shown somewhat lower fusing temperatures. The ashes from Lykens Valley coals have shown very much lower fusing temperatures, some such ashes fusing even below 2282 deg. F.

This lower fusing temperature seems to be coincident with relatively higher content of calcium oxide and sulphuric anhydride in the ash of the coal. The sulphur content of the coal itself, in the case of Lykens Valley coals, is very low, but much of this sulphur is left in the ash after burning, possibly in the form of calcium sulphate. Further work on this problem is highly desirable.

It might be remarked, in passing, that while the ash from Lykens Valley coal has a low fusing temperature, yet the ash from bony coal or slate has a fusing temperature above 2600 deg. F.

Unfortunately, our tests on coal ashes were made in a rather crude way. The ashes, molded into form of small cones, were heated in a muffle furnace over a coke fire, the temperature being determined by comparison with Seger pyrometric cones. The atmosphere, if we may judge from the appearance or color of the ash cones, was an oxidizing one.

We do think, however, that our work is of considerable value, at least from a comparative standpoint, and we submit the above statements as information modifying some of the conclusions reached by Selvig and Fieldner.

A. G. BLAKELEY.

Philadelphia & Reading Coal & Iron Co., Pottsville, Pa.

TABLE I.

Colliery	Fusing Temperature, Deg. F.	Silica, SiO_2 Per Cent	Alumina, Al_2O_3 Per Cent	Iron Oxide, Fe_2O_3, Per Cent	Calcium Oxide, CaO, Per Cent	Magnesium Oxide, MgO, Per Cent	Sulphuric Anhydride, SO_3, Per Cent	Phosphoric Anhydride, P_2O_5, Per Cent
No. 13	2210–2282	54.54	26.68	11.67	3.36	1.20	2.22	trace
No. 14	2210–2282	52.38	30.68	9.94	2.10	1.00	2.59	0.56
No. 15	2282–2390	55.43	26.81	9.14	3.76	1.85	1.52	0.48
No. 16	2282	56.35	29.91	9.54	0.98	1.10	0.51	0.40
No. 17	2462–2498	56.50	28.17	9.44	1.40	0.85	2.17	0.59
No. 18	2534	52.83	24.48	15.50	2.38	1.65	1.39	0.45
No. 19	Above 2534	55.78	30.91	10.64	0.45	0.50	0.10	0.23
No. 20	Above 2534	51.44	34.47	9.44	1.96	0.68	1.02	0.63
No. 21	Above 2534	55.84	32.79	7.55	0.71	1.10	1.15	0.39
No. 22	Above 2570	52.00	33.71	8.89	1.92	0.59	1.17	0.28
No. 23	Above 2570	54.28	31.22	11.67	1.21	0.44	0.69	0.24
No. 24	Above 2570	50.60	33.99	11.93	0.81	1.03	0.86	0.46
No. 25	Above 2570	52.94	37.66	7.22	0.56	0.55	0.69	0.27

Tin in Bolivia

To the Editor of Chemical & Metallurgical Engineering

SIR:—A study of the tin deposits in the world shows that Bolivia occupied a very prominent position, not only on account of the nature of the minerals found in its mountains, but also because of the wealth of its ore deposits. If we consider the various sources of tin, we find the most important to be as follows: The peninsula of Malacca, Banka, Billiton, Sumatra, Siam, New South Wales, Australia, Tasmania, New Zealand, Cornwall, Transvaal, Japan, Finland, China, Korea, Siberia. Other deposits of less importance in central Europe are in Spain, Portugal, France, Italy, Scotland, Ireland and the well-known deposits in Bohemia; some in the United States and Alaska; and none in South America except in Bolivia, which has gradually become second in importance as a producer of tin.

Nevertheless the tin deposits of Bolivia are very little known and up to date only a comparatively small section has been exploited, and that is the region which is richest and possesses minerals of the most desirable composition. In a word, it can be said that the only mines operated in Bolivia are those which contain extraordinary wealth. In the meantime in my opinion the real future of Bolivian tin industry lies in those deposits of lower grade which up to the present time have not been touched.

The country contains extensive deposits of tin in the principal mountain chains; and in some of the rivers

which rise in some of these mountains there are large alluvial deposits of tin which have never been exploited. In order to produce the metal in large quantities at a profit it would be necessary only to install large concentrating plants that would handle thousands of tons per day. To accomplish this it would be necessary first to interest American capitalists to make a study of the country and invest in Bolivia the large capital that would be required to make these installations.

I have always been surprised at the fact that the United States, itself the largest consumer of tin in the world, has never made the slightest effort to own its mines; and it is quite surprising that the United States has never taken notice of Bolivia, the country richest in this mineral, where it would be possible to make a development sufficiently extraordinary to supply the total consumption of North America.

Recently Mr. William S. Kies, vice-president of the American International Corporation of New York, visited Bolivia. I have had the pleasure of several talks with him on the subject of tin production and have called his attention to the fact that his country should make a study of Bolivia from the point of view of developing tin mines on a large scale. I trust that this may serve as a starting point for a business development that will be of mutual benefit to both nations.

La Paz, Bolivia. JUAN M. REYES.

Copper in Slags

To the Editor of Chemical & Metallurgical Engineering

SIR:—In the review of our article on Slags published in the last issue of your journal, there is a numerical error in the first column. You say that analyses of blast-furnace and reverberatory slags showed an average residue of 0.7 per cent Cu insoluble in $AgNO_3$, with an average deviation of only 0.11 per cent.

The figures should be 0.147 per cent instead of 0.7 per cent, and the average deviation should be 0.011 per cent. G. D. VANARSDALE.

Phelps-Dodge Corp.,
New York City.

The Analysis of Red Lead

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to the above heading in your issue of March 15, I have looked up the article published in the *Journal of Industrial and Engineering Chemistry* of March, 1916, and find that Mr. Schaeffer, in his application to the analysis of red lead, failed to give me credit for a prior application of the lead peroxide-hydrogen peroxide-potassium permanganate reactions in dilute nitric acid solution for determining lead (Ericson's lead method), although I have published several papers on the subject, viz.:

"A New Volumetric Method for the Determination of Lead," *Journal of the American Chemical Society*, September, 1904.

Later another paper on its application to spelter analysis entitled "A New Technical Method of Spelter Analysis" published in the *Journal of Industrial and Engineering Chemistry*, May, 1913. Other papers were published in the *Engineering and Mining Journal* at various times.

I have used this method daily (peroxidizing the lead by means of ammonium persulphate in ammoniacal solution, filtering, dissolving in a known excess of hydrogen peroxide solution, and titrating the excess by standard potassium permanganate) for a dozen years in the zinc industry and on Joplin ores principally, so it is strange that Mr. Schaeffer should not have heard about it. Several Joplin chemists have been acquainted with it, and some in the lead industry.

Mr. Schaeffer deserves credit for his ingenious application of my method to the analysis of red lead, but should have given me due credit.

ERIC JOHN ERICSON.

Philadelphia Meeting of the American Chemical Society

THE annual meeting of the American Chemical Society will be held at the Bellevue-Stratford Hotel, Philadelphia, Sept. 2 to 6, 1919. Unusual interest will center in this meeting on account of the consideration of important problems confronting the chemical industry. The adaptation to peace purposes of plants erected primarily for the production of explosives and munitions will be one of the important subjects under discussion. In this connection the Hon. Newton D. Baker, Secretary of War, has promised to make an address at the general meeting.

The division of industrial chemists and chemical engineering will have a symposium on refractories which will interest all who are concerned with furnace linings and processes where heat-resistance is required. Another subject to be considered by this division is the revision of the patent law, with particular reference to the charge of a renewal fee to prevent so-called patent pirates from keeping claims on file indefinitely with no intention of developing the patent. A representative of the Patent Office is expected to be present and an invitation has also been sent to A. Mitchell Palmer, Attorney-General, formerly Alien Property Custodian.

The newly constituted rubber section is expected to have a program of considerable interest.

The Philadelphia section is making arrangements for entertainment of visitors, and it is expected that all of the large chemical plants in Philadelphia and vicinity will be open. A boat trip on the Delaware has been arranged, and a visit will be made to the Hog Island Shipyard and the League Island Navy Yard. An automobile trip to Valley Forge and a smoker will be features of the entertainment.

The Philadelphia local section urges all who are able to attend the meeting to reserve hotel accommodations as soon as possible.

American Steel Treaters' Society to Hold Convention

In planning the first annual convention, to be held at the 7th Regiment Armory in Chicago from Sept. 22 to 27, inclusive, the American Steel Treaters' Society has decided to include an exhibit of freaks which have resulted from heat treatment. The members have been asked to contribute examples of tools that have, in hardening or tempering, acted contrary to all theory and ordinary practice or that have cracked, expanded, contracted, warped, etc., in an inexplicable manner. Other odd occurrences in heat treating iron and ferrous alloys will be shown. It is hoped that the interest aroused in this exhibit will result in an exchange of explanations and theories which will aid materially in increasing our understanding of the mechanism of heat treating.

Tariff Hearings on Tungsten

THE proposed tariff on tungsten ores and products as embodied in the Timberlake bill (H. R. 4437) was the subject of hearings before the Committee on Ways and Means, House of Representatives, June 13, 14 and 17, 1919. The bill provides for duties on crude tungsten ores and concentrates of $10 per unit WO_3, and on metallic tungsten, ferrotungsten, tungstic acid, salts of tungsten, tungsten steel and other tungsten products of $1 per lb. of tungsten contained therein. The purpose of the tariff is to stabilize the tungsten industry in this country and to prevent the dumping of foreign tungsten ore from countries where cheap labor prevails.

It was brought out that the domestic requirements for the next few years may be estimated conservatively at 5000 to 7500 tons of 60 per cent concentrates per year. Domestic production has provided about 60 per cent of our needs, the balance being imported. One witness was of the opinion that the proposed duty would still allow 50 per cent of the tungsten used in the United States to be imported. He stated that it was not contemplated that foreign ore would be shut out.

Evidence was introduced to show that Asiatic ore could be delivered in this country at $7 per unit and still afford the Asiatic miner a profit. Labor costs for coolies were reported as 40 to 47c. per day for men and 20 to 27c for women and children. Ore from Bolivia, however, during the war was delivered at New York for between $20 and $22 per unit, though probably it could now be delivered at $16 to $18 a unit. The cost of producing tungsten in the United States is impossible to estimate with accuracy. It may be great or small, varying with the ore body and the cost of development. As a consequence costs are so widely different that any attempt to correlate them is fruitless. In Colorado in 1918 costs were estimated to range from $15 to $33 per unit, with an average of approximately $20. California costs are lower, but the U. S. Tariff Commission estimates that one-half of the domestic output is produced at a cost from $10 to $15 per unit and that the remainder costs from $15 to $25 per unit, averaging, say, $20.

The status of the tungsten industry in the United States is one of complete inactivity if we except operation of one mine in Nevada. Since the declaration of armistice all other properties have been closed. The Colorado producers showed that some properties were dismantled and that millions of dollars worth of property was affording no return on the investment. Cost of producing in this district has been increasing with the depth of the mines and the reduced grade of the ore. At the outbreak of the war the price of tungsten ranged from $6 to $7 per unit and the industry was paralyzed. War demand caused prices to soar as high as $90 per unit early in 1916. Later the price fell off to $20 or $25 per unit. When the price fell to $17 per unit all of the mines closed. This figure therefore was considered the dead line for all except a very few American producers, and it was the opinion of one witness that the figure represented absolute minimum cost of production.

Witnesses expressed their belief that a duty of $10 per unit on tungsten ores and concentrates would enable domestic producers to develop tungsten resources so that national requirements could be met at any time. It was felt also that $10 per unit would practically cover the difference between the average cost of production in the United States and foreign fields. It was very clearly brought out that *ad valorem* duties were inapplicable to tungsten ores because they were simply an invitation to foreign exporters to declare a low valuation and thereby pay a low duty.

Zinc Ores and the Tariff

THE Joplin district zinc ore producers were represented before the House Committee on Ways and Means at a hearing held June 18, 1919. Paul A. Ewert, Otto Ruhl and E. B. Howard, Representative from Oklahoma, submitted testimony and exhibits to support the contention of the zinc-ore producers that a specific import duty of 2c. per lb. of zinc in ores containing over 25 per cent zinc was necessary to maintain the zinc mining industry in the Joplin district. The importation from Mexico of ores that were produced at a low cost, due to cheap labor, has practically closed the zinc mines in Missouri and Oklahoma.

The average cost of producing 60 per cent concentrates in the Joplin district during the first part of 1919 has been between $45 and $55 per ton, depending upon local conditions, whereas the average declared valuation of Mexican 30 per cent ore for the first three months of this year was $9.42. The cost of producing 1 lb. of zinc in Joplin concentrates is therefore about 37c. and from Mexican ore 1.5c. The producers therefore reason that the 2c. per lb. specific duty is justified.

The larger quantities imported during the war period came from Australia, Canada and Mexico. Table I shows the amounts. Table II shows the declared value of imported ore per ton compared with the average base price of Joplin zinc ore for same periods.

TABLE I. ZINC CONTENT OF IMPORTED ORE

	1914	1915	1916	1917	1918
Australia	....	11,130	56,726	23,237	789
Canada	4,345	4,040	8,092	5,540	6,300
Mexico	2,895	15,365	34,805	54,154	28,671

TABLE II—DECLARED VALUE IMPORTED ORE PER TON COMPARED WITH AVERAGE BASE PRICE JOPLIN ZINC ORE FOR SAME PERIODS

Year Ending June 30	Long Tons (2,240 Lb.)	Value	Value, Short Tons[1]	Value Joplin Zinc Ore
1914	18,280	$13.70	$12.23	$39.79
1915	79,814	22.77	20.33	54.16
1916	291,264	32.32	28.77	92.78
1917	262,767	28.57	25.50	73.57
1918	102,234	24.44	21.82	58.30

[1] Values of short tons of 2,000 lb. are computed in order to compare with Joplin ores, given in short tons.

All imported ore has been subject to a 10 per cent *ad valorem* duty. It was brought out in the hearing that the value to which the *ad valorem* duty is applied was furnished by the exporter and represented his valuation of the ore for export and at the port of shipment. There has been a large difference in the actual valuation at port of entry and this figure. It was brought out that in the case of Germany before the war there were two valuations of zinc ore—one for home consumption and the other for export.

The method adopted by the Treasury Department for ascertaining the value of zinc in imported ore arriving in the United States is as follows:

(1) From the ascertained assay deduct 8 units for sulphide and 6 units for non-sulphide ores. The re-

mainder will represent percentage of recoverable zinc in the ore, which multiplied by 2000 will give the number of pounds of zinc recoverable from a ton of ore.

(2) Multiply the result as above ascertained by the average price of prime Western spelter at East St. Louis for the week in which the ore was exported; that is, the week including the date of sailing of the ship or day the car leaves the foreign country. This will give the gross value of the zinc in the ore at the time of its exportation.

(3) Deduct from the gross value of the zinc in the ore as above ascertained the following:

(*a*) The freight actually paid from the foreign mine to the domestic smelter receiving same in the U. S.

(*b*) The insurance actually paid.

(*c*) The actual shipping charges.

(*d*) Foreign export duties and charges, if any.

(*e*) Treatment charge (as explained in par. 4).

(*f*) Penalties for iron (as stipulated in par. 5).

(*g*) Duty on lead contents, if any.

(*h*) Duty on zinc.

(4) *Treatment charge.* (*c*) For sulphide ores the treatment charge will be ascertained as follows: From the value of the recoverable spelter in a ton of 2000 lb. medium grade Joplin sulphide ore, 60 per cent base, deduct the average of the quoted prices for such ore and $1.50 per ton of 2000 lb. as representing the average freight on Joplin ores from Joplin, Mo., to common Kansas smelting points.

(*b*) For non-sulphide ores the treatment charge will be ascertained as follows: From the value of the recoverable spelter in a ton of 2000 lb. of 40 per cent calamine ore deduct the average of the quoted prices for such ore and $1.50 per ton of 2000 lb. as representing the average freight paid from Joplin, Mo., to common Kansas smelting points.

(5) *Penalties.* On iron ore deduct penalties as follows: $1 on each unit of iron in excess of 1 per cent up to and including 6 per cent; $0.50 per unit on each unit of iron in excess of 6 per cent up to and including 12 per cent; $0.25 for each unit of iron in excess of 12 per cent.

(6) The average market price of Joplin zinc ore and prime Western spelter to be taken in accordance with quotations contained in the *Engineering and Mining Journal* for the calendar week including the date of the sailing of the ship or day the car leaves the foreign country.

(7) Recoverable spelter, wherever that term is used in this memorandum, means for sulphide ores the assay minus eight units, and for non-sulphide ores the assay minus six units.

Congressional Hearings on Patent Office Bills

The House Committee on Patents began public hearings on July 9 on three bills relating to the Patent Office. One of these bills proposes to establish a United States Court of Appeals. The second bill would reorganize the Patent Office, remove it from the control of the Department of the Interior, and create an independent bureau to be known as the Patent and Trade Mark Office. The third measure proposes to revise the salaries and create additional department heads in the patent service. All three measures are fostered by the National Research Council.

One of the first to testify before the committee, of which Representative Nolan is chairman, was Fred T. Fish of Boston, a patent attorney, who urged the separation of the Patent Office from the Department of the Interior. Many other patent attorneys and experts are expected to present arguments to the committee, and the presentation of arguments has been placed in the hands of Mr. Prindell, secretary of the National Research Counsil.

It is understood that the committee is willing to hear anyone interested, and that it reserves to itself the right to amend the bills which were drawn by the National Research Council.

War Trade Board Transferred to State Department

Pursuant to an executive order signed by the President on May 12, 1919, the present personnel, duties, powers, functions and records of the War Trade Board have been transferred to the Department of State as of July 1, 1919.

This transfer will not affect or inconvenience the exporting and importing public in any way. The functions of the War Trade Board will continue to be performed by the present personnel in the building at Twentieth and C Streets, Washington, D. C.

All licenses will continue to be issued in the name of the War Trade Board, and all applications for licenses, and all correspondence pertaining to the activities of the War Trade Board, now assumed by the Department of State, should be addressed to the War Trade Board as heretofore.

The War Trade Board Section of the Department of State announces that it will issue licenses permitting the importation, on or after Sept. 1, 1919, of pig tin and all metal alloys containing tin, including tin drosses, tin oxides, solder drosses, type metals, antifriction metals, waste metals, and other metals containing tin, from points other than points of origin and without reference to the date of shipment.

Columbia University Fellowships

The General Bakelite Co. has provided the funds for an industrial fellowship in the department of chemical engineering of Columbia University. This fellowship differs from the general type of industrial fellowships in that, in addition to the amounts paid to the fellow and for the chemicals and apparatus used by the fellow, a sum is paid to the university to compensate it for the use of the laboratories and other facilities used by the worker. A further difference is that no time or other limitation is put upon the publication of the results of the investigation. Mr. Mortimer Harvey has been appointed to this fellowship for 1919-20.

Mr. George Barsky has been appointed to the Bridgham fellowship ($1500) at Columbia University for the year 1919-20. He will work in the department of chemical engineering with Prof. McKee on the utilization of the waste liquor from sulphite pulp mills. Mr. Barsky received the degree of Chemical Engineer in 1918 from Columbia University.

Investigating Water Resources in Canada.—The Canadian Government decided in Council held on April 19, 1919, to investigate and develop the water-power resources of the Dominion.

Quicksilver Produced in the U. S. in First Quarter of 1919

ACCORDING to figures compiled by F. L. Ransome of the United States Geological Survey, about 5960 flasks of quicksilver of 75 lb. net was produced in the United States from Jan. 1 to March 31, 1919. Returns from 23 productive mines gave a total of 5924 flasks, and it is estimated that 36 flasks was obtained from two or three small mines in California and Oregon whose operators were not heard from. Of the 5960 flasks produced, 4023 are credited to California, 1698 to Texas, 193 to Oregon and 46 to Nevada. No production was reported from Idaho or Arizona.

The quicksilver reported on hand at the mines or in transit to market at the end of the quarter amounted to 4419 flasks.

As was expected, the output during the first quarter of 1919 was considerably less than that during the first quarter of 1918, which was 8764 flasks. The decrease was 2804 flasks. The unsold stocks at the end of the first quarter of 1918 amounted to 2800 flasks, or 1619 flasks less than at the end of the first quarter of 1919.

The average monthly price of quicksilver in San Francisco, as quoted in the *Mining and Scientific Press*, for January was $103.75, for February $90, and for March $72.80.

The falling off in production is the result of a combination of causes, chief among which were a lessened demand for the metal and a consequent downward trend of prices, the continued high cost of labor and supplies, and the curtailment of underground exploration and development during the war, when energy was directed chiefly to immediate production. The price of quicksilver, compared with the prices that prevailed before the war, was still high at the end of the quarter, but not high enough to offset the general decrease in the tenor of the ore immediately available and the high cost of mining and treatment.

The Examination of Materials by X-Rays

A joint meeting of the Faraday and the Röntgen Societies was held April 29, 1919, in the rooms of the Royal Society. The chairman, Sir Robert Hadfield, in introducing the discussion, expressed his belief that in this method of examination there lay a great future for the detection of flaws in metals and other materials, such as wood and ferro-concrete, upon which the safety of human life often depended. Hitherto the method had been limited, so far as metals were concerned, in that it could be applied only to thin sections. Recently 4 in. of steel had been examined, and he believed that apparatus now in use would be able to penetrate iron and steel up to 9 in. in thickness.

Several interesting papers were presented dealing with the principles, apparatus and technique of radio metallography. Types of X-ray bulbs and tubes were discussed. The behavior of photographic plates to X-rays and the methods of obtaining contrast in photographs through metals were the subjects of two papers.

The practical application of the method relating to the examination of metals was presented in a paper by E. Schneider describing "Researches Into the Industrial X-Ray Examination of Metals at the Laboratories at Le Creusot Works." This paper summarizes: (*a*) Researches into segregation and blowholes; (*b*) examination of tungsten steels; (*c*) examination of compound metals; (*d*) location of blowholes, in order to avoid them in working.

Capt. R. Knox, M.D., and Major G. W. C. Kaye, M.A., presented a paper on "The Examination of Aircraft Timber by X-Ray." No difficulty was experienced in detecting concealed knots, resin pockets and grub-holes. Excess or deficiency of glue in glued joints is also readily revealed. Workmanship and material in the interior of completed laminated or box spans and struts have every detail shown up by the X-ray. The center veneers of plywood can be examined by the same means. In most instances the fluorescent screen suffices for this kind of work.

The X-ray examination of alloy steels and the nonferrous alloys and metals was suggested as an adjunct to the usual metallographical methods. Prof. W. H. Bragg thought it probable that by means of the diffraction effects of X-rays caused by the atoms of a crystal we should be able to examine the nature and extent of the crystallization of substances and thus gain much information to supplement that given by other methods. He also brought out the fact that generally speaking the transparency of a substance is greater the smaller the atomic weight.

American Dye Industry

THE present status of the American dye industry, both as to results obtained in spite of war-time difficulties and as to limitations in competitive ability, is clearly shown in a report submitted to the Committee on Ways and Means by the United States Tariff Commission. The report supplements and brings up to date the Census of Dyes and Coal-Tar Chemicals for 1917.

The production of intermediates has developed to such an extent that the industry is practically independent of imported raw materials; 354,808,315 lb., valued at $123,817,966, was produced during 1918.

The grand total of all finished products derived from coal tar (exclusive of explosives and poison gases) was 75,494,113 lb., valued at $83,095,404, reported by 162 firms. The total production of dye during 1918, reported by 77 firms, was 57,155,600 lb., valued at $61,306,040. This output in 1918 represents a gain of 24 per cent over 1917. Of even greater importance than the gain in output is the fact that over 300 dyes of improved quality were made during the year, over 100 of which represented varieties new to the American industry. In many cases prices of dyes were considerably reduced.

Synthetic indigo was manufactured by only one firm in 1917, the output being 276,000 lb. During 1918 two other firms entered the field, production increased to 3,083,888 lb., and it is stated that the present plant capacity is substantially greater than the pre-war importation, which, in 1913-14, was 8,507,359 lb. Over 12,000,000 lb. of sulphur black was made, as compared with 5,616,458 lb. imported during the fiscal year 1913-14. The corresponding figures for methyl violet, a triphenylmethane dye, are 632,196 lb. and 255,063 lb., respectively. Four azo dyes were produced in excess of one million pounds each; Alizarin yellow G, 2,233,208 lb.; scarlet 2R, 1,188,798 lb.; naphthylamine black 10B, 1,154,682 lb.; benzo blue 2B, 1,523,985 lb. Excellent progress is also reported in the preparation of coal-tar medicinals and photographic materials. It is

interesting to note that the reported production of the highly-prized photographic developer metol (methyl-p-amidophenol sulphate) is 10,975 lb., which is 393 lb. in excess of the 1913-14 importation.

In spite of the rapid advance made by the industry, much remains to be accomplished before German competition can be met. The great group of dyestuffs derived from anthracene, which includes the fastest dyes known, is practically undeveloped in this country. During 1918 only 119,774 lb. of anthraquinone and related colors was produced, while 3,300,000 lb. was imported in 1913-14. However, much experimental work has been done on these dyes and, provided that Germany is prevented from dumping her reserve stocks on the American market, we may expect a substantial increase in production and variety. It will be necessary to improve the methods used for recovering anthracene, so that the residual pitch may still be marketable as a road surfacing material.

Dyes and War Materials

As an instance of the close relationships existing between certain dyestuffs and war materials, the manufacture of sulphur black and picric acid is cited. The nitration of monochlorbenzol yields dinitrochlorbenzol, which may be converted into the sodium salt of dinitrophenol by boiling with alkali. This product gives sulphur black by treatment with sodium sulphide and sulphur, or, upon further nitration, picric acid which, in combination with calcium hypochlorite, forms chlorpicrin. It is obvious that a plant making sulphur black in peace times can quickly turn out picric acid and chlorpicrin in a war emergency. In addition, picric acid could be made from the phenol (produced synthetically from benzol or recovered during the fractional distillation of coal tar), used in peace times for the manufacture of germicides, medicinals, dyes, phenolic resins, synthetic tanning materials, etc. Normal consumption of phenol is estimated at 10,000,000 lb. per year, while the output for 1918 was 106,794,277 lb.

Licensing System Proposed

In order to determine the best method for protecting the dye industry during the final stages of its development, hearings were held before the Ways and Means Committee during the week of June 16. Joseph H. Choate, Jr., counsel for the Chemical Foundation and the American Dyes Institute, presented a brief showing the need for insuring a permanent domestic industry and outlining the proposed licensing system, which is not in the nature of an embargo, but is a temporary measure designed to admit those dyes which the Licensing Commission finds are unobtainable at reasonable prices from domestic sources. The Longworth bill for import duties on coal-tar products was accordingly rewritten to include a license system which will operate for five years to bar out all dyes and intermediates except as the American industry may need them. The Dye Licensing Commission is to consist of eleven members appointed by the President, five of whom will represent the manufacturers (three of these must be actually engaged in the manufacture of coal-tar dyes) and five the consumers (three of these must be actually engaged in the manufacture of cotton, woolen and silk goods, respectively). The remaining member, who will be the chairman, must not be connected with the dye industry, either as manufacturer or consumer.

Fall Meeting of the American Electrochemical Society

The tentative program for the Chicago meeting of the American Electrochemical Society, Sept. 23-25, 1919, has been announced by the board of directors. Several sessions will be held jointly with the American Institute of Mining and Metallurgical Engineers, which meets in Chicago during the week of Sept. 22.

On Tuesday, Sept. 23, the Society and Institute will go by boat to Gary, Ind., for inspection of the plant of the United States Steel Corp. A symposium on electric steel will be held on the boat and continued at the Congress Hotel in the evening.

Wednesday morning the Society will hold a general session and in the afternoon a joint session with the A. I. M. E. in a symposium on non-ferrous electrometallurgy. In the evening a special visit will be made to the electric furnace display at the National Exposition of Chemical Industries at the Coliseum.

Thursday will be devoted to a symposium on catalysis, to be followed by a smoker in the evening.

On Friday the Institute may hold its symposium on pyrometry, to which members of the Society are invited.

Headquarters of both the Society and the Institute will be at the Congress Hotel, and according to present plans all sessions will be held there.

The American Electrochemical Society's headquarters at the Chemical Exposition will be Booth 229, on the balcony of the Coliseum.

House Passes Water-Power Bill

The House of Representatives has passed the water-power bill in spite of the fact that it had become entangled in such a way as to jeopardize early action on it. The bill is substantially the same as the Administration measure which the House of Representatives passed at the last session of Congress and which the Senate failed to consider in the closing days of its session. The measure provides for the granting of fifty-year licenses to construct and operate hydro-electric projects in the United States. The Federal Water Power Commission, which is the licensing body, is composed of the Secretaries of Interior, War and Agriculture. Provision is made for the recapture of projects at the end of fifty years and for the regulation of rates.

The measure is now before the Commerce Committee of the Senate and will be taken up by a sub-committee of that body shortly after Aug. 1, when Senator Jones of Washington, chairman of the committee, is expected to return from a visit to Seattle. The other members of the sub-committees who will have jurisdiction over the bill for the time being are Senators Nelson, Lenroot, Bankhead and Fletcher. Friends of water-power legislation in Washington predict the early passage of the bill by the Senate, but in legislative circles at the Capitol it is well understood that the question of foreign affairs relating to the Peace Treaty and League of Nations will have an important effect upon the early passage of any legislation.

During the short debate in the House preceding the passage of the bill, attention was called to the fact that Congressional delay in providing for water-power development has been in large measure responsible for the power shortage that we experienced during the war, and that further delay should not be tolerated.

Notes and Data on Fixed Nitrogen Plants

COST figures at the Government's cyanamide process nitrate plant at Muscle Shoals were made public for the first time during the recent hearings before the Committee on Military Affairs of the House of Representatives. Tabulations were presented showing the detailed costs of manufacturing calcium cyanamide and ammonia gas, nitric acid and ammonium nitrate therefrom this spring when the plant was operated at 20 per cent of its capacity in a test run. An estimate is given also of the costs had the plant been operated at full capacity. No charges are made on such important accounts as interest on the thirty-odd million dollars capital invested or plant depreciation and obsolescence, taxes and insurance. Undoubtedly a very large percentage of the investment in the plant should be written off against war expenditures, as it was constructed at extraordinarily high cost to protect our army against any possibility of defeat due to nitrate supplies from Chile being insufficient or our inability to expand the by-product coal industry so as to obtain sufficient amounts of ammonia. General Williams, Chief of Ordnance, in reporting on nitrate reserve stocks estimated that 24 divisions (1,400,000 men) will use 400,000 tons of sodium nitrate per year. At the time of the signing of the armistice, Col. Burns reported that the Government possessed a stock of 700,000 tons of nitrate and an equivalent of 200,000 tons in finished explosives; 400,000 tons was turned over for agricultural use, leaving an equivalent of half a million tons for military reserve. This, in comparison with our 44,000-ton stock of nitrate at the beginning of the war, gives a good military index number.

In reply to Mr. Quin's question as to converting the

MANUFACTURING COST OF GRAINED AMMONIUM NITRATE AT U. S. NITRATE PLANT NO. 2

Item	Results of Two Weeks' Test at Approximately 20 per Cent Capacity, Production 950 Tons			Estimated Cost of Manufacture at 100 per Cent Capacity, Production 110,000 Tons per Year				
	Quantity per Ton of Ammonium Nitrate	Unit Cost	Cost per Ton of Ammonium Nitrate	Quantity per Year	Unit Cost	Total Yearly Cost	Cost per Ton of Ammonium Nitrate up to June 1, 1921	Cost per Ton of Ammonium Nitrate after June 1, 1921
Nitric acid	0.858 ton	$103.37	$88.69	94,380 tons	$61.98	$5,850,000	$53.18	$57.41
Ammonia gas	0.230 ton	287.22	66.06	25,300 tons	169.19	4,281,000	38.91	42.49
Steam power, compressed air, misc	.....	.....	1.47	.....	.....	156,000	1.42	.....
Labor	.....	.....	3.43	.....	.....	273,000	2.48	.....
Total	.....	.....	$159.65	.....	.....	$10,560,000	$95.99	.....
Overhead	.....	.....	4.22	.....	.....	200,000	1.82	.....
Total	.....	.....	$163.87	.....	.....	$10,760,000	$97.81	$105.62
Operating fee	.....	.....	5.00	.....	.....	550,000	5.00	.....
Total	.....	.....	$168.87	.....	.....	$11,310,000	$102.81	$105.62

MANUFACTURING COST OF WEAK NITRIC ACID AT UNITED STATES NITRATE PLANT NO. 2

(All figures computed on bases of 100 per cent acid)

Item	Results of Two Weeks' Test at Approximately 20 per Cent Capacity. Production 600 Tons			Estimated Cost of Manufacture at 100 per Cent Capacity. Production 94,380 Tons per Year				
	Quantity per Ton of Nitric Acid	Unit Cost	Cost per Ton of Nitric Acid	Quantity per Year	Unit Cost	Yearly Cost	Cost per Ton of Nitric Acid up to June 1, 1921	Cost per Ton of Nitric Acid after June 1, 1921
Ammonia gas	0.317 tons	$287.22	$91.05	29,920	$169.19	$5,070,000	$53.63	$58.56
Power, kw.-hr	344	.00738	2.54	32,500,000	.0045	146,000	1.55	.....
Compressed air	.....	.....	.....	.....	.....	.....	.....	.....
Miscellaneous	.....	.....	1.95	.....	.....	232,000	2.46	.....
Labor	.....	.....	3.96	.....	.....	136,000	1.44	.....
Total	.....	.....	$99.50	.....	.....	$5,584,000	$59.08	.....
Overhead	.....	.....	3.87	.....	.....	265,000	2.90	.....
Total	.....	.....	$103.37	.....	.....	$5,849,000	$61.98	$66.91
Operating fee	.....	.....	3.20	.....	.....	302,016	3.20	.....
Total	.....	.....	$106.57	.....	.....	$6,151,016	$65.18	$66.91

MANUFACTURING COST OF AMMONIA GAS AT UNITED STATES NITRATE PLANT NO. 2

Item	Two Weeks' Test at Approximately 20 per Cent Capacity, Production 350 Tons, Cost per Ton Ammonia			Estimated Cost of Manufacture at 100 per Cent Capacity, Production 55,220 Tons per Year				
	Quantity per Ton Ammonia	Unit Cost	Cost per Ton Ammonia	Quantity per Year	Unit Cost	Total Yearly Cost	Cost per Ton Ammonia before June 1, 1921	Total Yearly Cost per Ton Ammonia after June 1, 1921
Lime nitrogen	4,025 tons	$64.41	$259.25	222,260 tons	$37.65	$8,368,000	$151.54	$167.08
Soda ash	0.134 tons	41.60	5.57	7,400 tons	38.00	281,000	5.09	.....
Steam	8,000 lb.	.217	1.74	442,000 M.	.181	80,000	1.45	.....
Power, compressed air, and misc	.....	.....	1.02	.....	.....	48,000	.87	.....
Labor	.....	.....	9.93	.....	.....	300,000	5.44	.....
Overhead	.....	.....	9.71	.....	.....	265,000	4.80	.....
Total	.....	.....	$287.22	.....	.....	$9,342,000	$169.19	$184.73
Operating fee	.....	.....	11.90	.....	.....	657,000	11.90	.....
Total	.....	.....	$299.12	.....	.....	$9,999,000	$181.09	$184.73

MANUFACTURING COST OF CALCIUM CYANAMIDE AT U. S. NITRATE PLANT NO. 2

Item	Two Weeks' Test at Approximately 20 per Cent Capacity, Production 1450 Tons: Cost per Ton of Lime Nitrogen			Estimated Cost of Manufacture at 100 per Cent Capacity, Production 220,000 Tons per Year				
	Quantity per Ton of Lime Nitrogen	Unit Cost	Cost per Ton of Lime Nitrogen	Quantity per Year	Unit Cost	Total Yearly Cost	Cost per Ton of Lime Nitrogen up to June 1, 1921	Cost per Ton of Lime Nitrogen after June 1, 1921
Limestone	2 tons	$2.25	$4.50	440,000 tons	$1.75	$770,000	$3.50	.....
Coke	0.54 tons	9.75	5.26	118,800 tons	6.00	713,000	3.24	.....
Coal	0.26 tons	4.25	1.10	57,200 tons	3.50	200,000	.91	.....
Electrodes	44 pounds	.06	2.64	4,840 tons	120.00	581,000	2.64	.....
Power, kw.-hr	2,765	.00738	20.40	608,300,000	.0045	2,738,000	[1]12.44	.....
Miscellaneous materials	.....	.....	2.75	.....	.....	590,000	2.68	.....
Labor	.....	.....	11.35	.....	.....	1,014,000	4.61	.....
Total	.....	.....	$48.00	.....	.....	$6,606,000	$30.02	.....
Overhead	.....	.....	13.85	.....	.....	990,000	4.50	.....
Total	.....	.....	$61.85	.....	.....	7,596,000	$34.52	$34.52
Operating fee	.....	.....	3.12	.....	.....	686,000	3.12	.....
Royalties	.....	.....	2.56	.....	.....	689,000	3.13	6.99
Total	.....	.....	$67.53	.....	.....	$8,971,000	$40.77	$41.51
Preparing for fertilizer use	.....	.....	.....	.....	.....	550,000	2.50	2.50
Total	.....	.....	.....	.....	.....	$9,521,000	$43.27	$44.01

[1] When hydro-electric power from Muscle Shoals dam is developed we should be able to obtain power, under the same assumption as governs this table, at a maximum cost of $0.001 per kilowatt-hour. On this basis the cost of "cyanamide fertilizer" would be reduced from $40.77 per ton to $31.09.

nitrate plants over to the production of commercial fertilizer, Col. Burns said:

> I think that is a problem in itself, Mr. Quin. I doubt if anybody could give you a definite answer. I know that we hope to utilize the plants for manufacturing commercial fertilizer, but there are one or two problems that will have to be solved before one can definitely say that the scheme is feasible. In the first place, money has to be appropriated by Congress for the operation of the plants and we will undoubtedly have to prove to you that we have a commercial product. We know that we can produce cyanamide, which is an absolutely satisfactory material for war purposes, for the manufacturing of ammonium nitrate and other explosives, but cyanamide at present is not admitted to be a thoroughly satisfactory fertilizer.
>
> I doubt not that small amounts are satisfactory. When you mix cyanamide with the ordinary mixed fertilizers in very small quantities you get no toxic effects therefrom, but if you increase the percentage very materially you may get toxic effects. That is the subject of one of our lines of experimentation at the present time.

COMPARATIVE COST OF NITROGEN IN VARIOUS PRODUCTS

Item	Estimated Manufacturing Cost per Ton at No. 2	Market Price per Ton	Units of Ammonia per Ton	Price per Unit Ammonia
Cyanamide:				
Estimated manufacturing expense per present contract prior to June 1, 1921	$40.03	.....	24	$1.67
Estimated manufacturing expense per present contract after June 1, 1921	40.77	.....	24	1.70
Estimated manufacturing expense per present contract after June 1, 1921, assuming hydroelectric power from Muscle Shoals dam available	31.09	.....	24	1.30
Ammonia gas:				
Estimated manufacturing expense per present contract prior to June 1, 1921	181.09	.....	100	1.81
Estimated manufacturing expense per present contract after June 1, 1921	184.73	.....	100	1.85
Estimated manufacturing expense per present contract after June 1, 1921, assuming hydro-electric power from Muscle Shoals dam available	145.32	.....	100	1.45
Weak nitric acid (as 100 per cent):				
Estimated manufacturing expense per present contract prior to June 1, 1921	65.18	.....	27	2.41
Estimated manufacturing expense per present contract after June 1, 1921	66.91	.....	27	2.47
Estimated manufacturing expense per present contract after June 1, 1921, assuming hydro-electric power from Muscle Shoals dam available	53.22	.....	27	1.97
Ammonium nitrate:				
Estimated manufacturing expense per present contract prior to June 1, 1921	102.81	.....	42	2.44
Estimated manufacturing expense per present contract after June 1, 1921	105.62	.....	42	2.52
Estimated manufacturing expense per present contract after June 1, 1921, assuming hydro-electric power from Muscle Shoals dam available	84.72	.....	42	2.02
Ammonium sulphate, normally	.....	60.00	25	2.40
Sodium nitrate, at present	.....	81.50	19	4.29
Sodium nitrate, normally	.....	45.00	19	2.37

An agricultural research is now being made and it is expected that the present difficulties will eventually be overcome.

Plants Nos. 3 and 4 at Toledo and Anchor, Ohio, are to be salvaged. Six million dollars has been spent on each of them and they are only 20 per cent completed. Twelve million dollars has been used in the construction of No. 1, but certain process troubles have prevented operation. A commission has been sent to Germany to study the Haber process, a modification of which was to be used.

Blast-Roasting and Its Effect on Blast-Furnace Design

By Walter K. Mallette

Modern blast-roasting has resulted in great improvement in metallurgical practice at smelters throughout this country, and this has led to changes in design of various parts of the plant. This is more noticeable in the design of the modern blast-furnace than in any other part of the works.

Sintering of fine sulphides and the agglomeration of other fine material in this sintered product has resulted in a much coarser and more open charge in the furnace. This coarse charge offers less obstruction to the passage of the blast and has greatly increased the tonnage output of the blast-furnace. This improvement is much more noticeable in lead furnace practice than it is in the copper plants, where reverberatories have largely supplanted blast-furnaces.

A few years ago, blast-furnaces were invariably de-

signed with a short, abrupt bosh directly above the tuyeres. This bosh was ultimately eliminated from the end jackets and the ends of the furnace made straight. The necessity for a bosh of this type has been largely eliminated by blast-roasting of ores and the resultant coarsening of the furnace charge, as it is no longer necessary to support the charge at a point above the tuyere line in order to permit the blast to penetrate to the center of the furnace.

A modern lead blast-furnace, where sintering eliminates the fine material from the charge, should be designed with a gentle, continuous bosh from crucible to the top of the jackets and with perpendicular ends. The slope, or bosh, will depend upon the reduction in volume of the descending charge, the rate of descent being kept uniform from the top of the furnace to the tuyere line. The Bunker Hill furnaces are of this type and operate very satisfactorily.

The day of the brick top, supported on mantel beams, has passed, and modern practice is to use two tiers of water jackets surmounted by cast iron or cast steel plates. This provides a furnace unusually free from incrustation and eliminates the necessity for cutting the blast and barring down accretions. It also gives less obstruction on the furnace floor and, consequently, better working conditions.

The greater porosity of the furnace charge makes it desirable to increase the height of charge column so that, in place of the 15 or 16 feet which has usually been considered the best working height, 22 to 24 feet may now be carried with far greater success. This necessitates greater blast pressure and allows a slight increase in furnace width, so that an up-to-date lead furnace should have a width of about 50 inches, a charge column height of about 22 feet and use a blast pressure of about 60 ounces.

Such a furnace will operate with very little trouble. The higher blast-pressure will give a zone of intense action near the tuyere line and the furnace will be free from blow-holes. The elimination of hot tops reduces the dust losses and the high blast-pressure enables the furnace to handle variations in charge with great ease.

Compromise With Australian Practice

Riddell has pointed out some of the advantages observed by him in Australia on furnaces of this type, although the Australian practice goes to limits which are hardly applicable to the majority of ores in this country. It is rare that we would encounter conditions which would warrant a furnace 56 in. in width with a 27-ft. ore column. However, we can compromise between this extreme and our previous practice to material advantage.

The thimble top, adopted in some instances, seems to offer advantages, although it is doubtful whether this can be universally applied. At the Selby plant this method of drawing off the gases presents distinct advantages as hand feeding is still in use. The thimble, with stack or downtake protruding through the feed floor, adds complications to mechanical feeding, but it is quite possible that the thimble could be designed with the downtake below the feed floor, leaving the latter clear for the operation of charge cars. A downtake on each end of the furnace, connected to the thimble, would give the best results.

It seems quite likely that Arthur Dwight's idea, to which he gave expression some years ago, of feeding the furnace by means of belt conveyors will be practically applied in connection with the use of the thimble top. It is certainly feasible and would undoubtedly result in a considerable saving of labor.

Increased tonnages of output of the lead blast-furnace will lead, ultimately, to a trapped spout and a continuous slag flow.* This has not been attained as yet, but the period between taps has been so reduced, in some instances, as to bring this condition within reach.

Double roasting has eliminated the matte problem so that it is quite possible to operate a lead blast-furnace without matte fall. However, this is of doubtful value, as the presence of a certain amount of matte in the furnace keeps it in better condition and is worth the cost of retreatment in the improved furnace conditions. Keeping the matte fall to 2 per cent gives excellent results in the majority of cases, and this amount of matte is a valuable material with which to regulate the condition of the roast. A judicious use of matte will assure a good hard roast under almost any conditions, and in order to operate the blast furnace with the greatest success, the physical as well as the metallurgical conditions of the roast must be closely watched.

Reduction of Matte Fall in Lead Smelting

The reduction in matte fall has eliminated the great need for double settling, and the smelting of slag shells is also being gradually discarded, although there are still quite a number of metallurgists who maintain that a furnace cannot be successfully run without a bit of slag. With reduced matte fall and reasonable settling, the value of the slag shells is not much greater than in the discarded molten material and this will rarely pay the cost of rehandling and retreatment. It is more profitable to discard the shells and replace them with ores in which there is a margin of profit.

In the copper plants, the reverberatory still holds the front rank, but it seems likely that much of the work which is now done in the reverberatory furnace could be performed just as successfully in the blast-furnace in conjunction with blast roasting. There has been less change in the design of copper blast-furnaces than is the case with lead furnaces; blast-roasting cannot be said to have affected the design of copper blast-furnaces to any appreciable extent. The long Mathewson type of furnace is still in favor and continues to perform satisfactorily. Crucible plates have been lowered and are now set on I-beams resting on the foundations. Brick tops were eliminated a number of years ago and long, narrow jackets are very generally used.

The future may bring out improvements in copper blast-furnace design and practice which will make it once more a rival of the reverberatory, but it cannot be said to have been very greatly improved during the past five or six years.

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San Francisco, Calif.

Mineral Acid Production.—Mr. A. W. Hawkes, vice-president of the General Chemical Co., recently stated that at the close of the war the company was producing mineral acids at a rate of 420,000 tons annually. This is about two-thirds that of all the plants in the British Isles. The total production of the United States grew during the war from 3½ to 7½ million tons of 50 deg. B., with plants under way for nine.

*Editor's Note—"Mathewson" top was in use in Pueblo for many years.

Electrolytic Caustic Soda-Chlorine Cells

Review of the Patent Situation—Four Classes of Cells Defined: Diaphragm, Mercury, Bell and Fused Electrolyte—Chart: Product Proportions, Current and Energy Efficiency, Kilowatt Consumption and Current Cost Per Unit of Products

By KARL HORINE

THE basic patent[1] on caustic chlorine cells was granted to Charles Watt long before the era of dynamo generators and cheap electricity. Watt obtained his current from Daniel cells in series. Nevertheless prices were correspondingly high, for the chemical caustic soda and chlorine market still had fifteen non-competitive years ahead of it before Messrs. Solvay, Weldon, Deacon et al. were to initiate "The War of the Alkali Industry." Watt was an able chemist, as will be appreciated upon examining his patent description, which anticipates the actual development this process has taken, namely: Diaphram cells for the production of pure chlorine and alkali; fused electrolyte, metallic sodium, etc.; and mixed electrolyte, hypochlorites and chlorates.

Approximately three hundred inventors have received patents subsequent to Watt's invention. Billiter's[2] and Lucion's[3] Abstracts describe most of these. The former gives a digest of the patents on the diaphragm and bell type of cell on which there were 256 British, 136 German and 127 American patents granted previously to 1911. The American patents are in group 204—Electrochemistry, subdivisions 1, Aqueous Bath; 4, Anodes; 5, Apparatus; 6, Cathodes; 28, Diaphrams, and 58, Alkali and Chlorine. Less than twenty issues have been made since 1911 and a complete set of copies can be obtained from the Patent Office for about $7.

In conception the electrolytic method of making caustic soda and chlorine from brine is extremely simple. The requirements are merely a pair of electrodes and the passage of direct electric current from one to the other in the brine. The primary products formed in so simple a cell, however, would immediately enter into secondary reactions and not be available as desired. The numerous modifications of the simple cell that have been brought out represent just so many attempts to eliminate or control these secondary reactions. The merits of the several electrolytic processes will be better understood after reviewing the underlying facts of alkali chloride electrolysis.

Ampere-Hour Efficiency

When a current of electricity is passed through a solution of common salt, positively charged sodium ions pass to the cathode (negative electrode) and negatively charged chlorine ions pass to the anode (positive electrode). The chlorine ions give up their negative charges on contact with the anode and are liberated as free chlorine gas or remain dissolved in the liquid surrounding the electrode. At the cathode the sodium ions give up their positive charges and immediately react with the water of the electrolyte, liberating hydrogen and forming caustic soda. Thus the products of electrolysis are chlorine, caustic soda and hydrogen, all of which are valuable commercially. Unless prevented by the construction and operation of the cell the following secondary reactions are presumed to occur in some degree: The hydroxyl ions formed at the cathode will carry negative charges to the anode exactly as the chlorine ions do. These hydroxyl ions, however, have almost three times faster migration velocity than have the chlorine ions and consequently carry, in proportion to their concentration, a larger part of the current. Arriving at the anode, the OH ions are discharged, with the result that oxygen is set free, together with the chlorine. The sodium hydroxide, which must be in equilibrium with the OH ion passing through the anolyte, reacts with the dissolved chlorine, forming hypochlorite, chlorates and sodium perchlorate in solution, a portion of which are reduced by the carbon anodes forming carbon dioxide in the chlorine gas. The chlorine dissolved in the anolyte may also come in contact with caustic by diffusion with the catholyte and bring about the same secondary reactions.

The aim of the various processes is to remove the products, chlorine, caustic and hydrogen, from the zones of electrochemical activity as rapidly as they are formed and so to avoid the secondary reactions. If this were accomplished, no current would be used in secondary reactions, and the current efficiency would be 100 per cent; that is, each ampere-hour would produce 1.3220 g. of chlorine, 1.4910 g. of sodium hydroxide and 0.03759 g. of hydrogen. Ampere-hour efficiencies obtained in practice vary from 90 to 98 per cent.

Energy Efficiency

The energy efficiency depends not only upon the current officiency but also upon the cell voltage. The cell voltage may be considered as made up of two parts—the voltage of decomposition of the solution and that required to overcome the resistance of the solution and of the electrodes. The decomposition voltage of brine is approximately 2.3, and until the applied pressure exceeds this critical value no current is forced through the cell. Cells operate usually at from 3 to 7 volts, depending upon design, temperature and current density. If a cell had 100 per cent current efficiency and could operate at a pressure of 2.3 volts, its energy efficiency would then be 100 per cent. In practice energy efficiencies range between 30 and 75 per cent. The difference in voltage of different cells depends almost entirely on the current density and length of current path in the electrolyte. This is evident from the fact that the resistivity of 25 per cent or nearly saturated brine is 1.76 ohm-inch, or 2½ million times that of pure copper. Consequently a great area of electrolyte and a short

[1] Eng. Pat. 13,755, Sept. 25, 1851.
[2] Die elektrolytische Alkalichloridzerlegung, Part I, mit starren Metallkathoden, 284 pages. Part II, mit festen Kathodenmetallen, 180 pages.
[3] Electrolytische Alkalichloridzerlegung mit Metallkathoden (Hg or Pb).

current path are needed to avoid excessive voltage drop. In connection with the operation of plants for the production of chlorine and caustic soda electrolytically, it is desirable frequently to correlate various factors bearing on the cost of production. Repeated application of efficiency formulæ, calculations of kilowatt-hours per lb. of chlorine, etc., become irksome even when carried out on a well-oiled slide rule. As a short-cut the author has evolved the chart of co-ordinated curves shown herewith. The continued building of chlorine and caustic soda cells suggests that such a chart may be useful to others. It might readily be used by a plant operator or superintendent having no knowledge of the theoretical considerations on which it is based.

The use of the chart requires little explanation in addition to the example given. The operating current and cell voltage are read from indicating meters usually mounted on the power board. The number of pounds of caustic soda per hour is computed from the weight and concentration of caustic liquor.

Four Classes of Cells

Electrolytic chlorine cells comprise four processes, namely, the diaphragm, the mercury, the bell, the fused electrolyte.

The Diaphragm Process. In this process a porous partition, usually a molded absestos compound, separates the anode and cathode compartments. All types of diaphragm cells employ the same means of preventing the hydroxyl ions from passing to the anodic space, that is, the flow of the electrolyte itself is made to oppose their passage. The gases, chlorine and hydrogen, accumulate above the surface of the electrolyte and are readily drawn off. The sodium hydroxide is removed from the cathode in part by the flowing salt solution and in part by gravity. Whether it collects at the top of the cathode compartment, as in Le Sueur's cell, or at the bottom, as in the Griesheim, Townsend, Jewell and others, depends upon the relative concentration of brine and caustic where a mixture of these solutions constitutes the catholyte. Thus the specific gravity of a 26.4 per cent or saturated salt solution at 15 deg. C. is 1.2, and the caustic soda will float on the brine unless its gravity is equal to or greater than 1.2, that is, unless its concentration is above 17.7 per cent. A number of diaphragm cells, however, use oil, steam or even air in the cathode chamber.

The earliest commercially successful cell of the diaphragm type was the Griesheim, which was first operated in Germany in 1890. An iron box serves both as container and cathode. The anodes are plates of magnetic iron oxide. The diaphragms forming the walls of the boxlike anode compartments are a composition of cement, salt and hydrochloric acid. In use, the salt dissolves and leaves an extremely fine pored wall. It is essential in all diaphragm cells that this porous diaphragm allow electric current to pass through freely, but at the same time keep the caustic alkali of the cathode compartment from mixing with the saturated salt solution of the anode compartment. In the Griesheim cell the accumulation of the sodium hydroxide causes the waste of current from secondary reactions to increase and when about one-third of the sodium chloride has been decomposed it is necessary to shut down and draw off the caustic. Griesheim cells are steam-jacketed and the electrolyte temperature is maintained between 80 and 90 deg. C. The anode current density is from 10 to 20 amperes per square foot. Other diaphragm cells in operation are the Hargreaves-Bird, in Middlewich, England; the Townsend, at Niagara Falls; Le Sueur's, at Rumford Falls, Maine; the Outhenin-Chalandre, used extensively in France, Switzerland, Italy and Spain; the Billiter-Siemens, at Niagara Falls and in Europe; the Billiter-Leykam, in Austria; the Finlay, operating in Belfast; the Allen-Moore, at Portland and Philadelphia; the Nelson, in West Virginia; the Wheeler, in Wisconsin, and the Jewell, in Chicago.

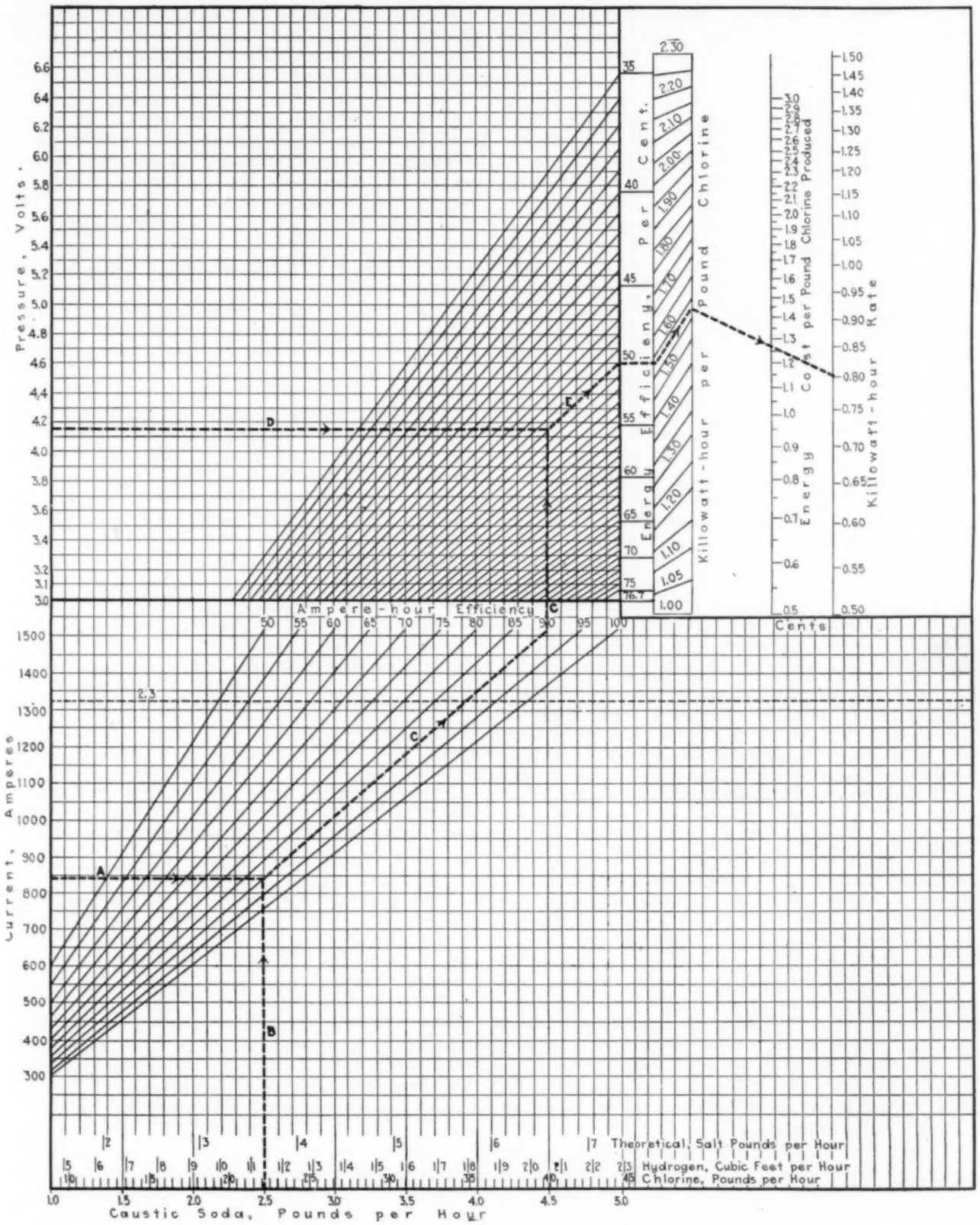
The Mercury Process. The mercury process uses anodes of carbon and a cathode of mercury. The sodium liberated by electrolysis amalgamates with the mercury and the amalgam is transferred mechanically to an adjacent compartment containing water. The amalgam is decomposed by the water, resulting in the formation of sodium hydroxide with the evolution of hydrogen and freeing of the mercury, which is returned to the electrolyzing chamber. Chlorine is collected above the anodes. NaOH so formed is very pure.

The Castner and Kellner cell in England was an early representative of this type. While the efficiencies are good, the initial cost is extremely high. A plant having a capacity of one ton of chlorine per day would contain about 13,000 lb. of mercury. Other mercury cells are the Solvay-Kellner, the Rhodin and the Wildermann.

The Bell Process. The bell type, of which the Aussig is the original, uses neither diaphragm nor mercury, but depends upon gravity for partial separation of the caustic soda and salt solutions. The chloride drawn off with the dilute caustic crystallizes out in the process of concentration of the caustic by evaporation. The Aussig comprises a bell of non-conducting material supported in an open tank. A carbon plate suspended horizontally inside the bell serves as anode and a sheet iron coating upon the outer surface of the bell constitutes the cathode. Brine is fed into the anode compartment. The current passes from the anode down under the edge of the bell and up to the cathode. Chlorine is drawn off through an opening in the top of the bell, while the heavy caustic formed at the cathode sinks and is drawn off at the bottom of the container. In practice a single tank contains twenty-five bells operating in parallel. The bell cells are free from diaphragm troubles, reliable in operation and low in initial and maintenance cost.

The Jewell bell-type cell is a modification of the older bell types. Stratification in its cathode compartment is aided by the addition of water and dilute caustic rises as formed. The Jewell claims ability to use impure brine, high current efficiency at high current densities and low cost for attendance and upkeep. The Jenkins is also a modified bell type of cell.

The Fused Electrolyte Process. This is also known as Acker's process and was at one time operated at Niagara Falls. The graphite pins which serve as anodes dip into a bath of fused salt. The salt floats on a cathode of lead maintained molten by the current it carries. The action is similar to that of the mercury process. The electrolyzed sodium forms an alloy with the lead, is removed from the cell and decomposed by steam to form sodium hydroxide and hydrogen. A current density of about 20 amp. per sq.in. of lead keeps the bath in a molten state. The concentration of caustic produced averages 94 per cent. The concentration of chlorine is 10 per cent, an extremely low figure. The energy efficiency is also very low.



ELECTROLYTIC CAUSTIC SODA-CHLORINE CELL CHART

Typical Solution of a Problem:

Given:

Operating current, *A*	840 Amp.
Operating pressure per cell, *D*	4.15 V.
NaOH produced per hour, *B*	2.5 lb.
Kw.-hr. rate	0.8 c.

Readings:

Lb. chlorine per hour, opposite 2.5 read	2.42
Theoretical lb. of salt per hour, opposite 2.5 read	3.66
Cu.ft. hydrogen per hour, opposite 2.5 read	11.4
Amp.-hr. efficiency, line *C* at intersection *A* and *B*, at end	90%
Energy efficiency, line *E* at intersection *D* with amp.-hr. efficiency, at end	50%
Kw.-hr. per lb. chlorine, on cross-scale, linear side, read	1.58
Energy cost, align 1.58 and 0.8 on logarithmic scale read	1.26c.

On the basis of efficiencies shown in published reports, an enterprise contemplating the manufacture of chlorine would select the Finlay cell. The selection of the type of cell, however, and the installation of a plant happen to require many other considerations such as initial cost, attendance charges, upkeep, floor space, overload capacity, cost of energy, continuous or off-peak operation, market for products, etc. While it is not to be expected that complete and reliable data on these various features can be available in so new an industry, there are a number of outstanding characteristics of processes and of individual cells that bear on the above named factors.

While diaphram renewal is necessary in cells of the diaphragm type, it is looked upon rather as a matter of cell upkeep than as operating trouble. Where the brine is properly pretreated the cells are operated from six to twelve weeks or even longer without serious falling off in efficiency or output. The mechanical cleaning of diaphragms in operation has been suggested, but the nature of the stoppage would seem to make this impracticable, if not impossible. Chemical cleansing of the cell pores is also unpromising on account of the activity of the chlorine on one side and of the caustic on the other. The diaphragm type cells are the most satisfactory on the market at present.

Offsetting the many advantages of the mercury cell are the comparatively large investment and large floor space required and the difficulty of removing impurities from the mercury. The high fixed charges can be compensated only by low energy costs, mercury cells being thus limited to regions of abundant water power.

The bell type require comparatively large floor space. Their low energy efficiency is offset by low investment, upkeep, and attendance charges. The possibilities of increasing the energy efficiency by decreasing the operating voltage offers a promising field for experimenters. The voltage above the brine decomposition voltage (2.3) is used entirely in overcoming the internal resistance of the cell. Since the resistivity of the electrolyte is about 400,000 times that of hard cast iron and 5600 times that of carbon, it is evident that, as pointed out above, by far the greater part of the voltage drop in a bell cell is due to electrolyte resistance and a very small part to electrode resistance. The problem, therefore, is to increase the area and decrease the length of the path of the current in the electrolyte and at the same time provide for the removal of the products of electrolysis without the undesirable secondary reactions. Because the area of the electrodes usually varies with the area of current path through the electrolyte and therefore with the voltage, undue importance seems to have been attached to electrode area and electrode-electrolyte contact resistance. Experience has shown that density of current in the electrolyte is the factor of prime importance. If the electrolyte current density factor is taken care of at all points, there will be no question of electrode-electrolyte contact resistance.

The capacity of rating of a cell should be based on the output of products of standard purity with maximum energy efficiency. The overload capacity would then be defined as the maximum rate of production which gives such standard products regardless of energy efficiency. Capacity stated in pounds or kilos of chlorine per 24 hours is definite; expressions such as "a 2000-ampere cell," sometimes used, are without meaning in stating capacities.

The value of overload capacity in the economics of production depends upon the relation among a number of factors. It is evident that to increase the output increase of the current density is required, and to increase the current density higher voltage, resulting in lower energy efficiency and higher energy cost of production, is required, but the higher rate tends to decrease the cost of production by cutting down the fixed charges. It follows that there is a point of maximum economy readily determinable in any given case. Thus it was found that a certain plant operating with highest ampere-hour efficiency at two tons of chlorine a day could be operated most economically at four tons a day.

The character of load afforded the central station by electrolytic chlorine plants is most attractive. The low voltage energy of unvarying amperage may, for many types of cell, be taken directly from a rotary converter at the available pressure, say 110 to 500 volts. For example, a type of cell using 1500 amperes at 3.5 volts could be connected 30 in series on 110 volts, in which case the required converter capacity would be 165 kw. Such a plant would produce, say, 2880 lb. of chlorine per 24 hr. Voltage regulation is unnecessary. In addition to these attractive features, such a plant, if equipped with the proper type of cell, permits of off-peak operation.

The increasing demand for chlorine, its numerous products and its by-products must lead to the development of a recognized standard type of cell comparable in efficiency, durability and ease of operation with other standard electrical apparatus. This ultimate type of cell will doubtless have an energy efficiency above 80 per cent; it will operate with little attention, and its elements will require renewing infrequently as do those of a storage battery. Ordinary impurities in the salt and water will have no effect on its efficiency and will be periodically removed as simply as a boiler is blown off.

Many cells now in use cannot be shut down without taking special precautions to prevent mixture of brine and caustic, destruction of anodes, or other bad effects. The ultimate type will be unaffected by interruption of energy supply.

With the development of the efficient and dependable cell for the production of chlorine will come the development of simpler and safer methods for its utilization. Which of the fields of its present application will come to demand the bulk of the output it is impossible to foresee. Most interesting to the chlorine manufacturer, to the central station power salesman and to the industrial engineer is the fact that wonderful growth in the electrolytic chlorine industry appears to lie immediately ahead.

Civil Service Examinations

Metallurgist (Male).—A vacancy exists in the Navy Yard, Norfolk, Va., at $2800 a year. Bachelor's degree in metallurgy or mining engineering and at least three years' experience in metallurgy, including inspecting and testing of metals, are required. Applications must be filed prior to July 29, 1919.

Metallographist (Male).—A vacancy exists at the Engineering Experiment Station, Naval Academy, Annapolis, Md., at $7.52 per diem. Applicant must have bachelor's degree in chemistry, engineering or metallurgy and must have had not less than one year's experience in the use of the microscope in the examination of metals. Examination closes July 29, 1919.

The Langmuir Postulates

An Introduction to Dr. Irving Langmuir's Theory of Chemical Reactions, Showing the Method of Determining the Physical Qualities of Chemical Compounds From Their Atomic, Ionic and Molecular Structure — A New Theory of the Constitution of Atoms and Molecules

BY ELLWOOD HENDRICK

I

THE address of Dr. Irving Langmuir delivered at the Buffalo meeting of the American Chemical Society on "The Arrangement of Electrons in Atoms and Molecules" made such a deep impression upon those who heard it, and the potentialities of the Langmuir postulates loom so large as applied to research, that we resolved to give our readers a report on the subject as soon as this could be made ready. The first original paper appeared in the June number of the *Journal* of the American Chemical Society. Owing to the intense concentration of the text it is not easy reading, even to the average chemist, and in what follows we shall not attempt to cover the field with thoroughness, or even to touch upon problems that require experience in applying the postulates. Our purpose is to write an introductory chapter, and to begin "further back" for the benefit of those who have not followed diligently the voluminous literature of research on the structure of atoms and molecules. We shall not even attempt to make the line clear between the Langmuir postulates and the work of other men in research whose conclusions are in part accepted. We are dealing with a new philosophy of chemistry which differs from that of the present text-books in various concepts, but which provides a definite means of determining upon the arrangement of atoms in combination, as well as that of electrons in atoms and molecules.

PRACTICAL VALUE OF THE THEORY

We shall try to give at least a glimpse of its amazing practicality when applied in the laboratory. It is, in effect, a new angle of attack which calls for new mental processes; and, as with any new tool, these seem difficult at first. When we state, however, that with adequate understanding and experience, it becomes possible to predicate the physical and chemical qualities of a substance, even to its crystalline structure, before it is synthetized; that it opens up a new and workable theory of valence; that it explains the curious manifestations of the elements of the rare earths and other elements in the periodic table, the irregularities of nitrogen, and the magnetic properties of the iron and platinum groups of metals, as but a part of its contributions, we need give no further emphasis to its value as an aid to technology as well as to research. We shall not undertake to make all these facts clear. Our purpose is to lure the reader into a consideration of the subject, so that he may approach Dr. Langmuir's present and future papers with that quality of interest which is warranted by their importance.

For lack of space and with a view to confining ourselves to the simplest features in this article we shall omit discussion of the principle involved in the secondary planes (Postulate I) in connection with the position of electrons in atoms of greater complexity, also the magnetic forces as indicated in Postulate V, and the illumination shed upon the great work of Werner, and refer the reader to the first paper in the June number of the *Journal* of the American Chemical Society for the explanations and a much more comprehensive discussion of the entire subject in a very condensed form.

We are indebted to Dr. Langmuir for a number of extended interviews, and we express our sincere obligations to him for his patience in exposition.

STRUCTURAL RESEMBLANCE OF N_2O AND CO_2

By way of indicating the workings of the theory let us take as an example two gases that we have not heretofore regarded as having any qualities in common: N_2O, or laughing gas, and CO_2. According to the Langmuir postulates, as we shall try to develop them in part, these gases display a remarkable resemblance in the structure of their molecules, containing each the same balanced number of positive and negative charges, and the same exterior arrangement of electrons, so that, were they magnified to visibility, and the kernels of the atoms hidden from view, we should be unable to tell them apart by looking at them. At least it is a fair guess that by looking at them, under these conditions, we should be unable to distinguish them, one from the other. Then we conclude that they must have certain physical properties in common. The figures which follow have not been published elsewhere at the present writing; we are indebted for them to Dr. Langmuir, who will present them later on with detailed explanation in the *Journal* of the American Chemical Society, but they will serve to indicate the points of remarkable similarity in the physical properties of two gases which Dr. Langmuir concludes to be similar in structure. The records are taken from unrelated pages of published works:

	N_2O	CO_2
Critical pressure, atmospheres	75	77
Critical temperature, deg. C.	35.4	31.9
Viscosity at 20 deg. C.	148×10^{-6}	148×10^{-6}
Heat conductivity at 100 deg. C.	0.0506	0.0506
Density of liquid at —20 deg. C.	0.996	1.031
Density of liquid at —10 deg. C.	0.856	0.858
Refractive index of liquid, D line 16 deg. C.	1.193	1.190
Dielectric constant of liquid at 0 deg. C.	1.598	1.582
Magnetic susceptibility of gas at 40 atmos., 16 deg. C.	0.12×10^{-6}	0.12×10^{-6}
Solubility in water, 0 deg. C.	1.305	1.780
Solubility in alcohol, 15 deg. C.	3.25	3.13

Both gases form hydrates, $N_2O.6H_2O$ and $CO_2.6H_2O$. The vapor pressure of the hydrate of N_2O is 5 atmospheres at 6 deg. C., while the hydrate of CO_2 has this vapor pressure at —9 deg. C. The heats of formation of the two hydrates are given respectively as 14,900, and 15,000 calories per gram-molecule.

The surface tension of liquid N_2O is 2.9 dynes per sq.cm. at 12.2 deg., while CO_2 has this same surface tension at 9.0 deg. C.

Thus N_2O at any given temperature has properties practically identical with those of CO_2 at a temperature of 3 deg. lower.

These results indicaate the similarity of the outside structure of the molecules.

Disagreement in Freezing Point

There is one property, however, that is in marked contrast to those given above: the freezing point of N_2O is —102 deg. C. while that of CO_2 is —56 deg. This may be taken as an indication that the freezing point is a property which is abnormally sensitive to even slight differences in structure. The evidence seems to indicate that CO_2 is slightly more symmetrical and has a slightly weaker external field of force than that of N_2O.

It would be hard to find such an array of coincidences unless there were reasons for them, and it is one of the purposes of this paper to show reasons for them, as we proceed.

All of these figures have been gathered by painstaking research in the past. They were uncorrelated and uninteresting. But in the light of this theory we find them ranging themselves into such subtle correlation as to cause them to function as parts of that greater whole which men of research are ever trying to discover. For decades these figures have been available. But in this case, as in that of other bodies which we shall consider later, the identical physical characteristics of those of like structure have remained unobserved.

II

At the end of the paper we present the postulates upon which the work is based, and we shall refer to them from time to time as we proceed. But, going "further back," as we promised to do, let us consider every atom as made up of two component parts: the electro-positive charges concentrated in the nucleus of each atom, which is individual and peculiar to each element, and the electrons which are electro-negatively charged, and which, from their positions about the nucleus, neutralize the positive charges on it. *The electrons are arranged in a definite configuration about the nucleus of each atom.* They are not of necessity held absolutely still. There is no reason why they may not move about, but the area of activity of each electron that forms a part of an atom is circumscribed within limits of space similar to that of its neighbor. Unlike the nuclei which, as we have just said, are held to be peculiar to each element, we consider the electrons to be all alike.

Now let us bear in mind the atomic numbers of the elements in the order of their atomic weights in the periodic table. They are: H, 1; He, 2; Li, 3; Be, 4; B, 5; C, 6; N, 7; O, 8; F, 9; Ne, 10; Na, 11; Mg, 12; Al, 13; Si, 14; P, 15; S, 16; Cl, 17; Ar, 18; K, 19; Ca, 20; Sc, 21; Ti, 22; V, 23; Cr, 24; Mn, 25; Fe, 26; Co, 27; Ni, 28; Cu, 29; Zn, 30; through to U, 92.

Atomic Number Coincides With Electro-Positive Charges

Thanks to the brilliant Moseley of Manchester, England, killed as a private soldier in the flower of his youth in the Gallipoli fight, we have confirmation of the statement that the atomic number of each element in the periodic table and the number of electro-positive charges on the nucleus of its atom are the same. Thus from the above we read that the number of positive charges on the nucleus of the hydrogen atom is 1; that of the lithium atom is 3; carbon, 6; nitrogen, 7, and so on, so that the table of atomic numbers is also that of the positive charges on the nucleus of the atom of each element. From this we gather also that the nucleus of the atoms of no two elements can be the same, and we learn, too, that the table of atomic numbers gives, in addition to the foregoing, the number of electrons that are attached to, and form part of, every atom of every element. There must be an electron to neutralize every positive charge, because the difference between an atom and an ion is that in the former every positive charge of the nucleus is satisfied with an electron, and is therefore neutral, while in an ion this is not the case. In an ion there are either more or fewer electrons than will completely balance the positive charge of the nucleus of the atom, or the nuclei of the atoms, which constitute it.

In acknowledging and accepting in part certain theories of W. Kossel and G. N. Lewis, Dr. Langmuir carries them further, with various changes and extensions, but, as already stated, for the sake of brevity we shall not attempt to indicate the specific authorship of each idea.

III

By themselves electrons repel each other, but in the presence of positive charges they show a disposition to arrange themselves into definite groups; they indidate a law, or series of laws, of configuration, and this is the first step in the present work. If, then, these groupings, these configurations, may be found complete in the most stable of the elements, and incomplete in others, we may infer that in the inert gases the electrons are satisfied, that they have fulfilled their tendency to conform to certain arrangements, and that the activity of other elements is due to the drive to conform as nearly as possible to the complete, and therefore inert, elements. The author of these postulates will have nothing to do with metaphysics in the development of his theories of the constitution of atoms and molecules, but we cannot resist the observation that in this pair-forming and octet-forming nature of electrons about positive charges we find suggested the tendency in nature toward a condition of balance and rest which is the basis of the great postulate of Gautama Buddha, and the substance of the ancient philosophy of the East.

Helium the Most Stable Element

Different elements do not behave the same; they differ in their nuclei and in their arrangement and number of electrons, but in this striving to become as nearly as possible like the fixed gases we find the key to all chemical phenomena. It behooves us, therefore, first to consider the most stable element, which is helium. The atomic number of helium being 2, the positive charge of its nucleus is 2, and it has two electrons. How are these arranged? There being but two they cannot follow an isometric system: the simplest would be the tetragonal system, having, like the earth, a polar axis and an equatorial plane (Postulate I). We imagine these two electrons as held by the positive charges of the nucleus very much as though the nucleus were in the center and the electrons each in the half of a complete shell, say, like a walnut-shell, that surrounds it. Neither electron crosses the plane which divides these two hemispherical shells. We might picture, as in

FIG. 1

Fig. 1, a cross section of the helium atom, cut a little above the equator, so as to show all charges, the positively charged nucleus indicated by ++ and each of the electrons by a — sign.

IV

This must be the most permanent arrangement of electrons about a nucleus: one electron in each half of a spherical shell, and neither trespassing upon the territory of the other. And while there is no reason to regard the electrons as stationary, save that each keeps within what we call its cell, it will be convenient for us to consider each as occupying its average position, which would be on an axis perpendicular to the plane which divides them. Here we have a complete satisfaction of the positive and negative charges with almost no force extending beyond the atom in any direction. Let us say the electrons have achieved a position of complete balance and contentment, thus making helium the most permanent substance known. Because there is practically no external force about the atoms, and the primary disposition of its electrons to form pairs is satisfied, the atoms do not form molecules; they remain independent and inert. So independent and inert are they that not only is He a gas, owing to the lack of external force about its atoms, but these atoms are readily separated, and its boiling point is therefore only 4½ degrees above absolute zero. We have, then, in helium, the achievement of the first electronic ideal: the grouping in pairs about a positive charge. Such a central part we consider to be common to all atoms except that of hydrogen: the nuclei varying from 2 to 92 positive charges, according to the element, and the first pair of electrons invariably next to the nucleus.

V

The next element to helium in point of stability is neon. Its atomic number being 10, we must find an ideal arrangement of its ten electrons. The nucleus has ten positive charges, and the conclusion is that the first pair group themselves about the nucleus, just as in helium, leaving eight positive charges to be satisfied. These eight electrons arrange themselves in a second shell outside that containing the pair, four in either hemisphere of the outer shell, and each in its own cell. A top view would appear as in Fig. 2, with the nucleus and pair hidden under the outer shell. A perspective view would be as in Fig. 3. These eight electrons, four in either hemisphere of the outer shell, we call an octet. This shell is twice the diameter of that including the pair below it, and its surface is four times as great. This is in order to give the same space or room to each cell. There are eight cells, and every cell in the outer shell of neon is occupied. Now since we hold that chemical activity emanates mainly from the outer shell of electrons, there is no occasion for chemical activity in neon. And bearing in mind this greater chemical activity of the outermost shell we shall follow G. N. Lewis in calling all that part of any atom that is within the outer shell, its *kernel*. The second disposition of electrons is to group themselves into octets, and here they have done it. We have a pair, and an octet, all balanced, all filling every available space, and so there is no chemical activity to neon. It is inert; it is a gas; it has a low boiling-point, and it does not form molecules. It is completely satisfied as it is, and next to helium it is the most stable element. The next element in order of stability is argon, atomic number 18. This is just like neon, except that, according to Postulate IV, each cell of the second shell contains 2 electrons, making 2 in the first and 16 in the outer shell. This is also a permanent gas. In krypton, atomic number 36, we have two in the first shell, 8 + 8 in the second, and have 18 still to dispose of. The third shell will contain 18 electrons; 9 in each hemisphere. One of these 9 electrons will go to the pole, and the remaining 8 will be distributed symetrically about it. The same thing happens in the other hemisphere. With xenon we have krypton as the kernal (except that the nucleus has 18 more positive charges) and the 18 more electrons are distributed in the same manner in the third shell, making 2 in each cell, and including one more in a cell at each pole. Niton follows as the last, with 32 electrons in the fourth shell, 16 in each hemisphere.

FIG. 2

FIG. 3

In other words, we assume these inert and stable elements to be made up of successive and consecutive groups of electrons about the nucleus of each, consisting of first the nucleus, next a pair of electrons, and then consecutive octets and double octets with a pair in the polar position whenever there is an odd number of electrons to be provided for in each hemisphere. According to Postulate IV, all inner shells must have their full quota of electrons before the outer shell can contain any, but we note that in the inert elements the outside shells have their full quotas also. *This is the very reason for the stability and inactivity of these elements;* the electrons are ideally placed, they are electrically balanced, there is a minimum field of external force about the outer shells, therefore they all are gases, and have low boiling points.

No element other than the inert gases has its outer shell satisfied, i.e., every cell of its outer shell occupied, and therefore the electrons in the outer shell are always striving to make pairs or octets with some other electrons. *This is the basis of all chemical combination and reaction.* We shall try to make this more evident as we proceed.

VI

When we consider hydrogen, atomic number 1, we have but a single charge and a single electron. We have not even a pair. The lone electron is ever trying to form a pair, and therefore the atoms pair off in molecules. Note, please, in Postulate VI that a stable pair may be held by *two* hydrogen nuclei. Of course the hydrogen molecule is not as stable as an inert gas, but compared with a single hydrogen atom which has an exceedingly short time factor for its separate existence, the hydrogen molecule is very stable. It has the lowest boiling point of all substances except He, being but 20 deg. absolute. Due to such complete saturation within itself its external force is slight, and it shows slight chemical activity until it is split up into atoms. The old *status nascendi* theory in regard to hydrogen worked well in that it referred really to unpaired hydrogen atoms. If we take from a hydrogen atom its single electron we have left of course the hydrogen ion.

Lithium with its atomic number of 3 has three electrons, of which two form a pair about its nucleus and which constitute the lithium ion, while the third is easily detached, because it tends to form pairs or octets. We read in Postulate VI that the two atomic ker-

nels can very rarely hold a pair of electrons as is the case with the H molecule. The lithium kernel already has its pair, and therefore it cannot get another nucleus into its kernel. The lithium atom with but one electron in its second shell produces a strong electrostatic field which extends into surrounding space. There being no free nuclei about which the single outside electrons can group themselves into pairs or octets, it is electrostatic force which holds the atoms together, a second upon the first, a third upon the second, a fourth upon the third, and so on, *ad infinitum*, so that it appears to build itself into a solid lattice work structure. Therefore it is a solid. It melts and boils with difficulty. Because of the free electrons it is a good metallic conductor, but for lack of enough available electrons to form octets on the outer shell it has no tendency to form molecules either in a solid, liquid or gaseous state.

Properties of Fluorine in the Light of the Theory

Fluorine has the atomic number 9, or one less than neon, so that it has a pair about the nucleus and seven in its outer shell, lacking but one electron to make the octet complete. The cumulative effect of its seven outside electrons to form an octet is so great as to give it intense chemical activity. If brought into contact with lithium it takes the electron from it and completes its octet, making the fluorine ion negatively charged, and leaving the lithium ion positive. Let us repeat this to make it clear. Fluorine has nine positive charges on its nucleus, and about it is, first, a pair of electrons, and then seven more in its outer shell. With seven electrons all placed in a shell with eight cells, and all seven trying to form an octet, the effort is likely to be intense. And it is. Nobody ever called fluorine inert! That lone extra electron of lithium in an outer shell (although, of course, the concept of shells and cells is a concept of space only) is pulled over to the vacant space in the fluorine outer shell. That leaves the lithium ion free. But with nine positive charges on the nucleus of fluorine and ten electrons now engaged, the fluorine ion becomes negatively charged because of ten eletcrons about its nucleus with + charge of 9. So too the lithium ion, which has a triple positive charge on its nucleus and has lost an electron, has now but two instead of three negative charges, which makes the lithium ion positive. The force, however, which holds this ion to the fluorine ion with its octet of electrons is electrostatic; there is no opportunity for pairs of electrons to be held in common by the two elements, therefore there is no LiF molecule. Every lithium ion is attracted to all the negative fluorine ions about it, and *vice versa*, so that it builds up a lattice work of the two ions, as in Bragg's salts. It is a solid, but it is a non-conductor, because there are no free electrons, every octet being satisfied. If, however, we melt it, then it becomes an electrolytic conductor, because the ions are then free to move around.

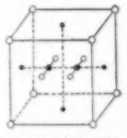
Relative Chemical Activity of Halogens

Here is an illuminating note which explains why the halogens decrease in chemical activity as they increase in atomic weight, and therefore in atomic number, while with the alkali metals the opposite is the case. Not only does fluorine stand next to neon, but all the halogens stand next to the inert gases, each having one electron less. Chlorine bears this relation to argon, bromide to krypton, and iodine to xenon. But as these inert gases increase in atomic number they become less stable, as is indicated by their decreasing ionization potentials and their increasing boiling points. There is greater distance or greater interruption between the positively charged nucleus and the negatively charged electrons in the outer shell as atomic numbers increase. Therefore it stands to reason, among the halogens, that as they increase in atomic number their electro-negative qualities decrease in intensity. On the other hand lithium stands next to helium, and the other alkaline metals bear a similar relation to the inert gases, each having one electron more rather than one less, as with the halogens. This lone electron on the outer shell is given up in the presence of a positive charge; it cannot well draw on seven other electrons to complete the octet. But the electrostatic force between the nucleus and the outermost electron becomes less and less as the kernel grows larger and larger, because the distance between the positively charged nucleus and the outermost electron becomes greater. Therefore the outermost electron becomes more readily detachable as the size of the atom increases, so that sodium is more electro-positive than lithium, while potassium is more electro-positive than sodium.

Carbon, atomic number 6. Here the atom is composed of a pair of electrons about the nucleus, and four in the outer shell. By virtue of the larger charge in the kernel these are not easily given up, as in lithium, but may be regarded as constantly trying to draw on four more electrons to make up an octet. The atom is symmetrical, and its tetravalency is persistent. Its well balanced but incomplete structure explains both its permanency in combination and its high boiling point.

Nitrogen and Its Compounds

Nitrogen, atomic number 7, with 7 electrons, cannot be brought into any symmetrical shape by doubling up its atoms to form N_2. We have the nucleus with its pair, and then five more electrons in its outer shell, which has room for eight, and the five electrons in the outer shell always trying to form an octet. The only symmetrical form in which we can consider two nitrogen atoms to constitute a molecule is to have them slide together into one, with two nuclei in the centre, each with a pair of electrons, which accounts for four of the 14 electrons in two atoms of nitrogen, leaving ten over. In the outer shell we have eight, and the remaining two may be held imprisoned within the octet. The arrangement (in a tetragonal form) would be as in Fig. 4. We saw a different kind of doubling-up in the hydrogen molecule, and it seems that this assumption for N_2 and a few other gases is a happy one.



Nitrogen Molecule
FIG. 4

Nitrogen forms a series of unusual compounds, some of which are remarkably active and explosive, and its structure indicates a signal departure in properties from the elements that precede it in atomic number. This single octet with a double kernel is not unique with N_2 although it is unusual. It is the only symmetrical arrangement of certain other bodies, and gives rise to some remarkable comparisons; more particularly of N_2 with CO, and also between these and HCN and NO. Let us compare the N molecule with the CO. The N molecule we have indicated above, with two nuclei, and a total of 14 positive charges, and a pair of electrons about each nucleus, two more imprisoned, and a com-

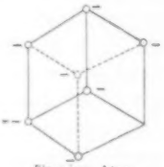
plete octet in the outer shell. The CO molecule is like it, with its 14 electrons arranged as in N_2, but with the two nuclei differently charged, being one nucleus with a positive charge of six for carbon and one with eight for oxygen, but also making a total of 14. The outer shells of these two bodies are the same, but their kernels differ. Now let us observe how these two gases resemble each other in physical properties for the very reason that their structures are so much alike.

	CO	N_2
Freezing point in deg. abs.	66	63
Boiling point in deg. abs.	83	78
Critical temperature	122	127
Critical pressure, atmospheres	35	33
Critical volume	5.05	5.17
Solubility in H_2O at 0 deg. C.	3.5	2.46
Density of liquid at boiling point	0.793	0.797
Viscosity, $\eta \times 10^6$ at 0 deg. C.	163	166

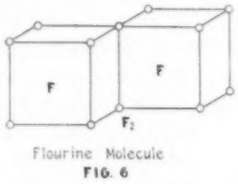
VII

The above is another remarkable example of physical similarity, due to what Dr. Langmuir calls isosterism; to similarity of the molecular structure of the two bodies. But in order to get what follows clearly in mind and to explain why we have pictured the N and CO molecules as tetragonal in shape rather than as spherical, let us enter into further explanation, even at the expense of repetition:

The helium atom with its nucleus and pair of electrons is the type of the innermost shell of every atom; the difference being only in that the nucleus has two positive charges, while the others, except hydrogen, have more positive charges. Since neither electron crosses the equatorial plane, we picture the atom as a nucleus, surrounded by a spherical shell, and each electron as placed within a fixed hemisphere of the shell. There is no reason to feel convinced that the electrons are held in a position of absolute stability, although we must assume that the position of each is circumscribed by the boundaries or walls of its cell. And we can well maintain that its average position is the center of its cell. When two electrons are in a cell we consider them to be placed, as to average position, one above the other, so that when, for instance, two octets are within a shell, we consider these two octets as in



Flourine Atom
FIG. 5



Flourine Molecule
FIG. 6

layers of eight. Since, according to Postulate I the central shell is divided only by an equatorial plane and the polar axis extending through the second shell and beyond is perpendicular to this equatorial plane, we have in an octet, a symmetry of electrons like that of a tetragonal crystal. Now, having conceived the atom as a sphere, it may seem an undue stretch of the imagination to call it a cube, but from the beginning we have claimed that the positions of the electrons are arranged with tetragonal symmetry. And since from now on we shall deal with electrons as they are arranged in the atoms, and since shells and cells are merely concepts of space, we shall picture every atom containing an octet as cubical in form. The octet is completed, then, when every corner of the cube contains an electron. Shells that contain more than eight electrons contain always multiples of eight cells, if we disregard those that are placed in the polar axis.

Suppose we go back for a minute to the fluorine atom with its nine electrons. There is the nucleus with its pair, and seven corners of the cube engaged. Let's make a working picture of it, Fig. 5. Then another fluorine atom will mate with it to form a molecule, as in Fig. 6. There are 16 corners of the two octets or cubes, all engaged, and each with an electron, but in two places one electron is in a corner of both cubes. The pair of electrons is shared, in other words.

VIII

Now let us develop the theory of octets which forms the basis of what Dr. Langmuir calls *covalency*, to distinguish it from valency in the generally accepted term. We shall not have much trouble here, if we address ourselves to the problem of observing how it works. The main difficulty is that we must take a new point of view, and anything new is likely to be bothersome.

The Langmuir theory of chemical combination is that these cubical atomic structures want to cover their corners with electrons so as to form complete octets. That is the way they try to complete their octets so as to settle down in life as much as possible like the inert

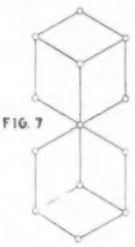


FIG. 7

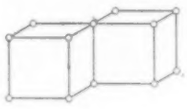


FIG. 8

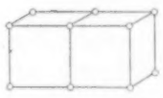


FIG. 9

gases, which is the electronic ideal. And we must remember that these cubes do not connect up on their corners. One electron held in common, as in Fig. 7, never holds two atoms together. They connect up either edge to edge, or side to side, so that there is either one pair of electrons, or two pairs, held in common by two combined atoms as in Figs. 8 and 9. It is very rare that the atoms coalesce, as in nitrogen, carbon monoxide, etc., for only under pressure of grim necessity will one atom join with another, making a single cube of two. The rule is as we have stated, either in single or double pairs between two atoms.

Determination of Covalency

This is covalency, and Dr. Langmuir has developed the following equation which shows us the necessary structure of the combinations from which we can determine the covalency.

$$e = 8n - 2p$$

or

$$p = \frac{8n - e}{2}$$

in which e is the total number of electrons available in the outer shells of all the atoms of a molecule; n is the number of atoms capable of forming octets, and p is the number of pairs of electrons held in common by the octets. (Postulate VIII.) Another symbol in frequent use is E, which indicates the number of available electrons in the outer shell of an atom. Available electrons means those forming incomplete octets, or, as with hydrogen, incomplete pairs. Thus, for instance, $E = 1$ for H, Li, Na, etc.; 2 for Be, Mg, etc.; 3 for B; 4 for C and Si; 5 for N and P; 6 for O and S; 7 for the halogens, and zero for the inert gases because the

octets are complete and the electrons therefore unavailable.

The equation expresses the fact for every pair of electrons held in common between octets, there is a total of two less—a decrease of two—in the number of electrons contained in the outer shell of all the atoms of a molecule. In other words, two of the electrons, the pair that is held in common by two octets, serve for the same edge in two atoms. This we explained in regard to the fluorine molecule.

Covalency Defined

The formation of molecules of compounds, therefore, depends upon the formation of octets, except in the case of hydrogen, of which the ion (which is the nucleus of this element) takes its place between two electrons. *Then the covalency of an atom is the number of pairs of electrons that it shares with adjacent atoms.* We shall soon see that covalency is not the same as valency, although covalency is in full accord with the valency theory in connection with organic compounds wherever formulas are written with carbon having a valency of 4; nitrogen 3; oxygen 2; hydrogen 1. But when it has been necessary to assume a valency of 5 for nitrogen and phosphorus; 4 or 6 for sulphur; 3, 5 or 7 for chlorine, then it gives results totally different, but in better agreement with the facts.

We can get a better idea, however, of the working of covalency by applying the rule. Let us use as our example a familiar salt, $NaNO_3$. Repeating the equation $p = \frac{8n - e}{2}$ we have one electron available from Na which has the atomic number 11, and is therefore like neon, but with one more electron which is available in the outer shell; 5 for the nitrogen atom as we have already explained (N having atomic number 7 and so having 5 in the shell outside of its nucleus and pair) and 3 times 6, or 18, for O_3. So: $e = 1 + 5 + 18$, or 24. There are 24 available electrons in all the atoms of the compound. Then n, or the number of atoms capable of forming octets, would be 1 for nitrogen and 3 for O_3. Sodium with its one lone electron in the outer shell will give it up rather than gather on seven more, so Na is incapable of forming an octet. Therefore $n = 1 + 3$, or 4. Then $p = \frac{8n - e}{2}$ or $\frac{(8 \times 4) - 24}{2}$ or $\frac{8}{2}$ or 4.

FIG. 10

Now let's make a picture of it in Fig. 10.

The Play of Electrostatic Force

Here we have two octets complete, with four pairs, held by octets in common. It provides for our NO_3 and it took an electron from the Na atom to do it, leaving the Na ion out in the cold; the Na ion being, of course, the Na atom with its one available electron extracted. But since the Na ion is positively charged we do not need any inexplicable valency to hold it on; it will stick on of itself.

The Na ion is positive because it has lost an electron which has wandered over to complete the octets in NO_3. The Na nucleus has 11 positive charges and this ion has but 10 electrons, so it must be positive. Conversely, the NO_3 ion is a negative, because its atoms, originally electrically neutral, have taken up the extra electron from the sodium atom. To make this abundantly clear let us note that the total positive charges on the nuclei of NO_3 (7 for N, and 3×8 for O_3) are 31, while there are 32 electrons in the ion: 24 in the shells and 8 altogether in the 4 kernels. It must be negative, therefore, with 31 positive charges and 32 electrons negatively charged. So with an opposing charge for each of the two ions, positive for that of sodium and negative for NO_3, we have no need of other valency. The electrostatic force will hold all the positive and negative ions together, not in molecules, but built into a lattice of the entire mass, in alternate fashion, each Na ion attracting all the NO_3 ions about it, and vice versa. They do not produce molecules; they produce balanced Na^+ and NO_3^- ions, held together by electrostatic force.

When $NaNO_3$ is molten it becomes an electrolytic conductor, because under the influence of an electric field its ions are able to move. In solid $NaNO_3$ the ions already exist, and when it is brought into contact with water the high dielectric constant of this weakens the electric field which holds the ions together, allowing them to separate, which accounts for the ready solubility of the $NaNO_3$ in water. And, dissolved in water, it is, of course, a good electrolytic conductor because the ions are already separated from one another.

It is interesting to note that only within the past year three remarkable papers have appeared, by Milner in England, Ghosh in India, and Bjerrum in Germany, showing from different viewpoints and from independent work that strong electrolytes are completely ionized, even in a strong solution. The octet theory leads inevitably to the above conclusion, and apparent discrepancies in the law of mass action are thus accounted for. The same method of argument applies to all salt-like substances, and in all these salts the covalency of the metal ions is zero. They do not form molecules because their ions are held together by electrostatic force and not by covalency, that is, by the sharing of pairs of electrons between them.

IX

The theory of covalency becomes simple with practice, although it lacks the *ipse dixit* quality of the valence theory. It cannot be learned by heart; in every instance it has to be reasoned out, but by the aid of the octet equation the complete picture may be rapidly visualized. We have already stated that it is in full accord with, or is the exact equivalent of, the valence theory in connection with organic compounds when the formulas are written with a valency of 4 for carbon; 3 for nitrogen; 2 for oxygen, and 1 for hydrogen, but that the results differ when it is necessary to assume a valency of 5 for nitrogen and phosphorus, 4 or 6 for sulphur; 3, 5 or 7 for chlorine. These will be explained in future papers by Dr. Langmuir, in which such compounds as those of phosphonium, sulphonium, oxonium, diazonium, etc., are particularly well accounted for. The method of application, however, is somewhat similar to that of ammonium, which we shall now consider. In the meantime we must bear in mind that 4 is the highest covalency an atom can possibly have, because no atom can engage itself with one or more others by sharing over 4 pairs to form an octet.

In NH_4Cl the octet rule shows that p (or pairs of atoms held in common) $= \frac{8n - e}{2}$ in which n (the number of atoms capable of forming octets, being Cl and N but not H) is 2, and e (or total number of all the

electrons available in all the atoms) is 7 for Cl, 5 for N, and 4 for H_4, or 16. So we have $p = \frac{16 - 16}{2}$ or 0. so that the N and Cl atoms have no pairs in common, although each is capable of forming octets. Then the hydrogen nuclei, being positively charged because they have each lost one electron, will tend to dispose themselves, each one between two electrons on the nitrogen octet. Their electrons have gone; one to complete the chlorine octet and the remaining three to do this same with the nitrogen atom. Now these hydrogen ions can also distribute themselves, one to the chlorine atom and three to nitrogen to produce HCl and NH_3, but by attaching themselves each to the four pairs of electrons on the nitrogen ion there is achieved a greater symmetry, and the hydrogen ions will do this until the temperature is so increased as to drive the nitrogen and chlorine ions apart from each other. Then one of the hydrogen ions, having its electron taken by chlorine, will follow it, and pair off with it between two electrons, giving us NH_3 and HCl. But with ammonium chloride we have as its two parts NH_4^+ and Cl^-. The ammonium ion is positive for the obvious reason that, with five nuclei, there are 11 positive charges, 7 for nitrogen and 4 for H_4, and only 10 electrons negatively charged to match them. On the other hand, the Cl^- ion carries in its complete octet one more electron (taken from a hydrogen atom) than the number of positive charges on its nucleus, and therefore it is negative. The equation taught us that the number of pairs shared by octets was 0. Ammonium chloride therefore is a salt, the ions NH_4^+ and Cl^- are held together by electrostatic force, and so it does not form molecules; in solution the ions become separated, and therefore it is an electrolytic conductor.

We observe from this nitrogen cube with an electron at every corner, and hydrogen ion held by every pair of electrons, that NH_5 is impossible. It also indicates why NCl_5 does not exist. NH_4^+ is an ion, and not a compound because it contains one hydrogen nucleus that lacks its electron, which in this case went over to the chlorine atom. There is nothing to indicate a valency of 5 for nitrogen in the octet theory.

Similarity of Ammonium and Potassium Compounds

A curious feature of the NH_4^+ ion is that it is surprisingly like the CH_4 molecule. They have the same number of electrons, the same structure, and they differ only in the electric charges of their respective nuclei. The hydrogen ions are held in the same way; both carbon and nitrogen forming complete octets, and both have hydrogen ion for every respective pair of electrons in the outer shell. Let us note at this point that the potassium ion—the potassium atom with one electron taken from it—is similar in structure to the argon atom except for the fact that the argon nucleus carries 18 positive charges and the potassium nucleus 19. Argon and CH_4 are very similar in their boiling points, etc. The fields of force of Ar and CH_4 are very similar, and the potassium ion differs from Ar just as the NH_4 ion differs from CH_4. Now things that differ equally from similar things are similar to one another, and it stands to reason that the K ion and NH_4 ion are as closely related to each other as are argon and methane. Therefore the K and NH_4 salts should be similar. And they are with remarkable frequency isomorphous in their crystal forms, and similar in their solubility and other physical characteristics. The same argument may be used to show that the NH_4 ion resembles the K ion much more closely than it does that of Na, since the Na ion has a structure like that of neon, in that it differs from it only in the electric charge of its nucleus. Ne being 10 and Na 11. Since neon does not resemble CH_4 as closely as does argon, it follows that the Na ion does not resemble the NH_4 ion as closely as does that of K, and the conclusion is amply supported by the physical characteristics of their respective salts.

X

Isosterism. We have already considered pairs of substances which when found to be closely related to each other in their several structures, prove to have remarkable relationships. When two substances have the same number and arrangement of electrons they are said to be isosteric. N_2 and CO are examples and show isosteric resemblances. If, then, besides the isosteric quality they have the same total number of positive charges in their kernels (or in all the nuclei in the molecule) then we shall expect the external field of force to be approximately the same in both cases, leading to approximate identity in physical properties. If the nuclei differ in their total charge, then one of the isosteres may be electrically charged when the other is not, so that the forces around the respective molecules become very different; then most of their properties will also differ.

Relationships of Isosteres

This subject of isosterism abounds in evidences of the reasonableness of the Langmuir postulates and we find that closely related structures show closely related physical relationships, so that we can even trace them beyond the isosteres. We have noted the similarity of structure of the CO and N_2 molecules, which are true isosteres. We have seen that because of the isosterism of CH_4 and NH_4^+ and that of Ar and K^+ and from the similarity of CH_4 and Ar, it follows that NH_4^+ and K^+ are similar, although not isosteric. We cannot compare atoms with ions, but we may reason that if Ar resembles CH_4 then an ion that is isosteric with argon will also resemble another ion that is isosteric with CH_4.

If two substances, besides being isosteres in having the same number and arrangement of their electrons, have also the same number of positive charges on the nuclei of all their atoms, then we have a right to expect the external field of force to be approximately the same in both cases, and that they will have approximately identical physical properties. On the other hand, if the positive electric charges on the nuclei of the atoms of two or more isosteric substances differ, then the forces around the respective molecules will differ, and most of their physical properties will differ. Thus the potassium ion and the argon atom, although isosteric, are differently charged, and we find them totally different in their physical and chemical properties. But we can make use of their analogies to other bodies, and thus trace out relationships which are of great aid in indicating the probable nature of these substances.

We shall give a number of instances of isosteric substances with observations made by Dr. Langmuir which will form parts of articles to appear later in the *Journal* of the American Chemical Society.

We gave early in this paper the coincidence of figures in relation to the properties of N_2O and CO_2. Now we can undertake to give the reason for them. The

octet rule shows $p = 4$ for both. So we have three cubes—three blocks, let us say—to be put together so they have four pairs of electrons or edges jointly. The simplest form would be three in a row, and we have N-O-N, or N-N-O as in Figs. 11 and 12. And we have covalences—in this case of 4 for O and 2 for N; or 4 for one N and 2 for the other N. and 2 for O. CO_2 must be O-C-O, Fig. 13, and we then have $\overset{7+}{N}\ \overset{8+}{O}\ \overset{7+}{N}$ or 22 positive charges on the 3 nuclei. With CO_2 we have $\overset{8+}{O}\ \overset{6+}{C}\ \overset{8+}{O}$ also 22 positive charges on the nuclei of its 3 atoms. There are 24 corners to the three cubes, but as 4 pairs of electrons are held

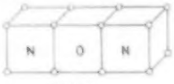


FIG. 11

FIG. 12

FIG. 13

in common we need 24 — 8 electrons, or 16 electrons, in the outer shell of each molecule—and there they are!

Let us cite a few other examples, more particularly with reference to the crystal forms: ClO_4^-, SO_4^{--} and PO_4^{---}. These are isosteric, therefore we should find similarities in the crystals of their salts. Investigation brings out the following: $CaHPO_4$ and $NaHSO_4$ crystallize in triclinic pinacoids, showing the following axes and angles of their axes:

	a	b	c	α	β	γ
$CaHPO_4$...	0.6467	1	0.8244	84° 57′	89° 43′	85° 38′
$NaHSO_4$...	0.646	1	0.837	85° 06′	88° 57′	86° 47′

or almost wholly within the limit of experimental error, notwithstanding the marked difference in solubilities and similar physical properties.

These observations infuse life into Groth's otherwise dreary *Chemische Krystallographie.*

Again, $KClO_4$ and $SrSO_4$ are isosteric; they belong to the orthorhombic system, and show the following ratios of their axes:

	a	b	c
$KClO_4$	0.7817	1	1.2798
$SrSO_4$	0.7790	1	1.2802

Double refraction is positive in both and they show the same cleavages. They are, as are the others, typical cases of isomorphism, and thus afford direct experimental proof that $KClO_4$ and $SrSO_4$ have similar constitutions. The octet theory indicates that the central atom in both compounds has a covalency of 4. The usual viewpoint of the chemist is that the valency of Cl in $KClO_4$ is 7, while that of sulphur in $SrSO_4$ is 6. But the fact that these compounds are isomorphous encourages the belief that the rutinary theory with valencies of 7 for Cl and 6 for S is wrong.

Isosteric Nature of Apparently Unrelated Compounds

Here follow more preliminary notes, to be dealt with in detail later by Dr. Langmuir:

$SrHPO_4$ and $KHSO_4$ are orthorhombic-pyramidal in form; their angles of axes are:

	a	b	c
$SrHPO_4$	0.8607	1	1.9344
$KHSO_4$	0.8581	1	1.9431

The optical axis in each is in (001) plane, and the habitus of the crystal forms are practically identical.

NaF and MgO are isosteric and are isomorphous in their crystal structures, according to measurements recently made by the X-ray method by Dr. Hull.

Corresponding salts of HN_3 and HCNO are isosteric, and the data in the literature, as far as they go, show that their solubilities are the same.

KN_3 and KCNO are both tetragonal: their ratios of axes are below:

KN_3	1 : 0.5798
KCNO	1 : 0.5766

Both give strong negative double refraction, and both have (001) and (111) as their most common crystal faces.

Let us conclude the list with mentioning a couple of salts that never were supposed to show any twin-like qualities: $Na^+ NO_3^-$ and $Ca^{++}\ CO_3^{--}$ which are almost identical in crystalline form, optical properties and cleavage. This is now accounted for by the fact that the NO_3^- and CO_3^{--} ions are isosteric. Since the force holding the Ca^{++} and CO_3^{--} ions together is four times as great as that holding Na^+ to NO_3^- it is more difficult to separate the ions, from which we understand why $CaCO_3$ is but slightly soluble, whereas in $NaNO_3$ the ions are easily separated in such a dielectric solvent as water, and that when the ions are separated, $NaNO_3$ becomes an electrolytic conductor.

XI

The theory, as may be observed, opens up vast possibilities. We can imagine periods of perplexity and dizziness after we have tried with sticks and balls of wax to build up atoms and molecules in the almost infinite number of chemical possibilities and we almost dread the task. It is usually difficult to present things of three dimensions in drawings of two, and the Langmuir atoms and molecules and compounds are all of three dimensions. We may have been somewhat negligent of this concept rather than ignorant of it in our methods heretofore. Whether this generation will take its chemistry in cubical atoms and build up its molecules and compounds in block-houses according to these postulates rests in the lap of the future for determination, but we think them too full of promise to be neglected for years as was Willard Gibbs' phase rule. We regard the work as a contribution of the first moment to the science of chemistry. And we believe that, as they are developed and revised and applied in practice, they will become familiar and easy of comprehension. We subjoin a revised list as of the postulates prepared for a forthcoming article on the subject by the author of the system.

XII

The Langmuir Postulates

I—The electrons in atoms are either stationary, or rotate, revolve, or oscillate about definite positions in the atom. The electrons in the most stable atoms; namely, those of the inert gases, have positions symmetrical with respect to a plane passing through the nucleus at the center of the atom. No electrons lie in the equatorial plane. There is an axis of symmetry (polar axis) perpendicular to the equatorial plane through which four secondary planes of symmetry pass, forming angles of 45 deg. with one another. These atoms thus have the symmetry of a tetragonal crystal.

II—The electrons in any given atom are distributed through a series of concentric (nearly) spherical shells, all of equal thickness. Thus the mean radii of the shells

form an arithmetric series 1, 2, 3, 4, and the effective areas are in the ratios 1; 2^2; 3^2; 4^2.

III—Each shell is divided into cellular spaces or cells, occupying equal areas in their respective shells, and distributed over the surface of the shells according to the symmetry required by Postulate I. The first shell thus contains 2 cells, the second, 8; the third, 18, and the fourth 32.

IV—Each of the cells in the first shell can contain only one electron, but each other cell can contain either one or two. All the inner shells must have their full quotas of electrons before the outer shells can contain any. No cell in the outside layer can contain two electrons until all the other cells in this layer contain at least one.

V—When the number of electrons in the outside layer is small these electrons arrange themselves over the underlying ones, being acted on by magnetic attractive forces. But as the charge on the kernel or the number of electrons in the outside layer increases, the electrostatic repulsion of the underlying electrons becomes predominant, and the outer electrons then tend to rearrange themselves so as to be as far as possible from the underlying ones.

VI—The most stable arrangement of electrons is that of the pair in the helium atom. A stable pair may also be held by: (a) a single nucleus; (b) two hydrogen nuclei; (c) a hydrogen nucleus and the kernel of another atom; (d) two atomic kernels (very rare).

VII—The next most stable arrangement of atoms is the octet, that is, a group of electros like that in the second shell of the neon atom. Any atom with the atomic number less than 18 and which had more than three electrons in its outside layer tends to take up enough electrons to complete its octet.

VIII—Two octets may hold one, two or sometimes three pairs of electrons in common. One octet may share one, two, three or four pairs of its electrons with one, two, three or four other octets. One or more pairs of electrons in an octet may be shared by the corresponding number of hydrogen nuclei. No electron can be shared by more than two octets.

History of Prices During the War

The Price Section of the War Industries Board is preparing a series of bulletins covering thoroughly the whole field of prices from the beginning of 1913 to the end of 1918. These bulletins will be completed and issued as soon as possible.

There will be 57 in all, the first seven being of a general nature. Each of the remaining fifty will be devoted to an important industry and of these the following (numbered from 30 to 57 in the order given) will be of interest to chemists and metallurgists:

Rubber and rubber products; paper; fibers and fiber products; iron, steel and their products; ferro-alloys, non-ferrous and rare metals; coal and coke; petroleum and petroleum products; matches; clay products; sand and gravel; quarry products; cement; glass; lumber; paints and varnishes; mineral acids; heavy chemicals; miscellaneous inorganic chemicals; fertilizers; soaps and glycerine; essential oils, flavoring and perfumery materials; wood distillation products and naval stores; natural dyestuffs and tanning chemicals; coal tar crudes, intermediates and dyes; drugs and pharmaceuticals; proprietary preparations; explosives; miscellaneous organic chemicals.

Melting Point of Asphalts

By Leland M. Proctor

AS ASPHALTS or bituminous materials are not true chemical compounds, but rather an intimate mixture of a large number of different compounds, they have no definite melting points. That is, there is no critical temperature which can be observed at which they pass from a solid to a liquid state. Therefore, a stated melting point will depend upon the method used and the conditions under which it is observed, and is purely arbitrary. Each method will give a different temperature for the melting point, and thus the method should always be given when writing of the characteristics of bituminous substances.

The following data were obtained on asphalts manufactured: No. 1, from Mid-Continent residual oil; No. 2, from a mixture of Mid-Continent and Mexican residual oils; No. 3, from Mexican residual oil; and No. 4, from a mixture of Mexican residual oil and residual oil from the Burton process. These asphalts have very different physical characteristics apparent to the casual observer. Four different methods, the Richardson ball, or over mercury, method, the General Electric method, the Kramer and Sarnow method and the ball and ring method, were used for these tests.

Table of Chemical and Physical Characteristics

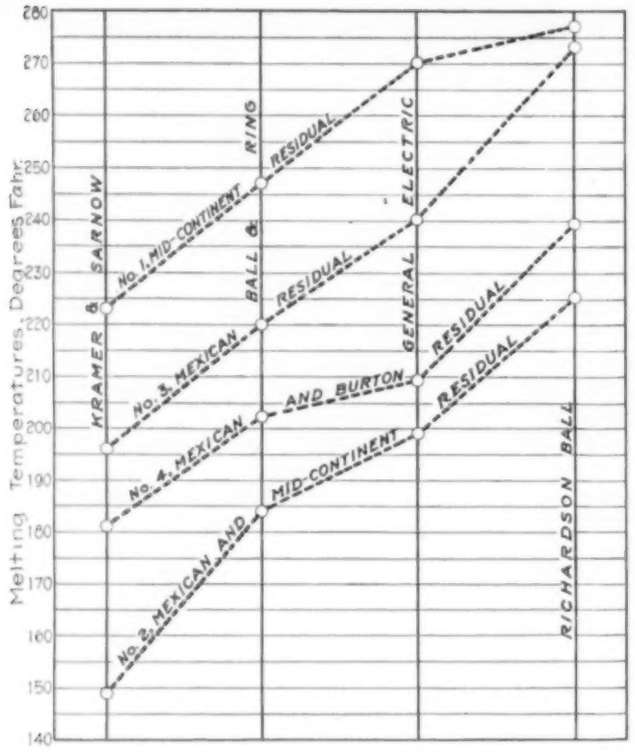
The following table of chemical and physical characteristics will give a much better conception of the asphalts used:

	No. 1	No. 2	No. 3	No. 4
Carbon tetrachloride soluble	98.79	98.47	99.05	82.90
Carbon bisulphide soluble	99.87	98.94	99.47	97.59
Ethyl ether soluble	75.82	71.95	67.28	69.71
Naphtha soluble, 88 deg.	87.50	76.45	96.28	77.36
Fixed carbon	17.78	19.57	24.44	28.40
Mineral matter as ash	0.14	0.048	0.421	0.163
Penetration at 77 deg. F., 100 g., 5 sec.	23	17	13	3
Ductility at 77 deg. F. in cm	2.00	3.20	3.2	0.10
Specific gravity at 77 deg. F	1.0026	1.028	1.054	1.135
Flash point (open cup)	506	468	471	444
Burning point (open cup)	582	584	558	519

A short description of each method follows. It is not the aim here to give them in any great detail, as these can be more accurately obtained from some of the few good texts on the subject of bitumens. Failing access to these, however, they are given sufficiently fully to enable one to carry out the operations and to obtain results which will be accurate within the limits of manufacturing.

The Richardson Ball or Over Mercury Method

The apparatus consists of 150 cc. beaker about half filled with mercury, mounted on an iron stand, with a thermometer suspended so that the bulb is immersed in the mercury. On the surface of the mercury is placed a miscroscope slide, thus forming a mirror. The sample of asphalt is rolled into a sphere about the size of a French pea, heating, if necessary, to free from all nicks and creases. This is placed on the microscope slide and the top of the beaker covered with a cardboard to protect the sample from drafts. Heat is applied in such quantity that the temperature is raised at the rate of 10 deg. F. per minute. When the ball is first placed on the slide it appears with its reflection as two spheres, one over the other, touching at a single point, but as the temperature rises it gradually flattens out on the bottom until the melting point is reached, which is the point at which the half round sample and its reflection make a single sphere.



AVERAGE EQUIVALENT MELTING POINTS BY K & S, BALL & RING, G. E. AND RICHARDSON TESTS ON FOUR ASPHALTS

The General Electric Method

A small quantity of the asphalt is melted and the bulb of a thermometer immersed in the liquid, withdrawn, and while the asphalt is cooling the thermometer is rotated horizontally. The process is repeated until enough material adheres, when it is rolled on an amalgamated brass plate, until a cylinder slightly smaller than a pencil is obtained. With a hot knife the lower end is cut off so that it is of uniform thickness throughout. The thermometer is now inserted in a cork, cut so as to reveal the graduations on the thermometer scale, and placed in a test tube so that the end of the thermometer is one inch from the bottom of the tube, and the whole is placed in a sulphuric acid or a glycerine bath so that the level of the liquid is above the top of the sample in the thermometer. Heat is then applied in such quantity that the temperature rises 5 deg. F. per minute. As the temperature rises gradually the sample slips on the thermometer and the point at which it first touches the bottom of the test tube is taken as the melting point.

The Kramer and Sarnow Method

A small quantity of asphalt is melted in a suitable dish and the end of a glass tube 5 mm. inside diameter and about 8 cm. in length is thrust in to a depth of about 7 mm., withdrawn and the asphalt allowed to cool while the tube is rotated horizontally. When the asphalt is sufficiently cooled so that it no longer flows, the asphalt adhering to the outside of the tube is cleaned away and 5 g. of mercury is placed on the asphalt in the tube. The tube is secured to the thermometer so that the sample and bulb are at the same level, and both are suspended in a glycerine bath. Heat is applied in such quantity as to rise at the rate of 4 deg. F. per minute. As the temperature rises the mercury gradually sinks out of sight, forming a pocket, and the point at which it breaks through and falls to the bottom of the beaker is taken as the melting point.

The Ball and Ring Method

The ball is polished steel, $\frac{3}{8}$ in. in diameter, weighing between 3.45 and 3.5 g. The ring is of brass, $\frac{5}{8}$ in. inside diameter, $\frac{1}{4}$ in. deep, with walls $\frac{1}{32}$ in. thick, fastened at right angles to a wire. A small quantity of asphalt is melted in a tablespoon and poured into the ring, which is set on an amalgamated brass plate, allowing for shrinkage. When it is cool the excess is cut off with a hot knife and the ball set on the asphalt in the ring. The wire is inserted in one hole of a two-hole cork and through the other a thermometer is inserted so that the bulb is at the same level as the ring, and the whole is suspended in a glycerine bath 1 in. above the bottom of the beaker. Heat is applied in sufficient quantity to raise the temperature at the rate of 10 deg. F. As it is heated the ball gradually sinks into the asphalt, coming through and forming a pocket with the ball inside. The temperature at which the pocket touches the bottom of the beaker is taken as the melting point.

Comparative Determinations

As will readily be seen, there is no relation between the melting point as specified by one method and that of another method, each giving a different temperature.

Sample	Richardson Ball	General Electric	Kramer and Sarnow	Ball and Ring
		FIRST TEST		
No. 1	275	271	214	246
No. 2	225	203	141	174
No. 3	271	236	191	219
No. 4	236	214	175	198
		SECOND TEST		
No. 1	275	266	233	249
No. 2	224	193	152	187
No. 3	273	243	196	214
No. 4	239	205	181	204
		THIRD TEST		
No. 1	277	274	223	248
No. 2	226	202	156	190
No. 3	276	242	200	226
No. 4	243	208	186	204
		AVERAGE		
No. 1	276	270	223	247
No. 2	225	199	149	184
No. 3	273	240	196	220
No. 4	239	209	181	202

A study of the tables shows this fact very strikingly, that there is a decided difference in the melting points as taken by the different methods and also that for any two asphalts having different characteristics the difference is not the same. Thus, taking the method giving the highest results, the Richardson ball method, the following table of differences can be obtained:

Asphalt	ΔT Richardson Ball and General Electric, Deg.	ΔT Richardson Ball and Kramer and Sarnow, Deg.	ΔT Richardson Ball and Ball and Ring, Deg.
No. 1	6	53	29
No. 2	26	76	41
No. 3	33	77	53
No. 4	30	58	27

This variation can be accredited only to the difference in the character of the asphalts. No. 1 is a short fibered, comparatively soft, very slow melting paraffine base asphalt greasy to the touch. No. 2 is a long fibered, soft, tenacious, slow melting mixed base asphalt. No. 3 is a long fibered, comparatively hard, tough asphalt base asphalt. No. 4 is a hard, brittle, shining bright, quick melting, mixed base asphalt.

The Richardson ball method gives very close checks, is rapid, simple and several different samples can be run at the same time. It can be taught very easily to the ordinary workman and thus lends itself nicely to the purposes of factory control. The apparatus can be easily cleaned by dipping the slide into the mercury while hot and wiping with a cloth. It has this disadvantage, the personal error enters in to a greater extent than in any others in the matter of judging when the ball is completely down and in estimating the size of the sample.

The General Electric method gives fair checks, but is unsuited to factory control on account of the slowness —only one can be taken at a time unless a number of thermometers and tubes are used—and the work of cleaning the tube is tedious. The personal error enters in the rolling of the cylinder on the thermometer to a little less than the size of a pencil.

The Kramer and Sarnow method gives rather the poorest checks of these four methods, though some texts credit it with far greater accuracy than was obtained in these tests. The method is more or less complicated and tedious, taking more apparatus than any of the others in that the mercury must be weighed out within reasonable limits. As many different samples may be tested as can be conveniently observed at the same time, but this advantage is balanced by the time necessary to clean the apparatus.

The ball and ring method has been adopted by the American Society for Testing Materials as a standard for this class of materials, and gives very good checks. The method is well adapted to specifications, because when the conditions are standardized the results may easily be duplicated by any other observer, the personal error being practically eliminated. It is not, however, very well adapted to factory control, as but one sample can be tested at a time.

Lockland, Ohio.

The Explosion of Chemicals—I Common Law Liability

By Chesla C. Sherlock

THE legal liability of an employer for injuries caused to his workmen by means of the explosions of chemicals which they are required by the duties of employment to work with must necessarily divide itself into two classifications—common law liability and the liability under the workmen's compensation acts. While the common law liability is not so generally operative as it was a few years ago, it still remains in many jurisdictions, so a consideration of the question can by no means be complete without first discussing it. Besides, the workmen's compensation system springs out of the common law system and its abuses, so that a complete understanding of the common law liability is necessary before any light can be cast upon the liability under the compensation acts.

Under the common law, it was a settled principle that the employer should provide his workmen with a reasonably safe place in which to work, safe appliances and tools and give them competent instruction in the use of such tools and as to the best manner of carrying on the work to be done. Furthermore, if the employer, by reason of his superior knowledge or position to acquire knowledge, should know of facts which might endanger the workman, it was his duty to warn the workman of these dangers and risks, especially in the case where the workman was young, inexperienced or new at the work.

In the case of dangerous tools or appliances or materials complicated in nature, it was the duty of the employer to exercise care and caution to keep them in a state of repair or to handle them in such manner that they did not become dangerous through defective condition or operation to the workman. If the employer lagged in this respect, he was very apt to find himself guilty of negligence and liable in an action for damages to the injured workman.

On the other hand, through long continued following of precedents and customs in determining what the law was, a great maze of decisions raised a barrier around the injured workman so that in obtaining his recovery he was put to such lengths that it was practically impossible for the average workman to realize anything for his injuries. What he did recover generally went for the costs of litigation and attorneys' fees.

Among these rules, the common law held that if a workman were guilty of contributory negligence, no matter how slight that negligence might be, he could not recover damages from his employer for the injuries suffered. If he was injured by the negligence of a fellow servant, he could not recover from the employer for the injury sustained, because the employer could not be held responsible for the negligence of another person, even though that person were his employee. If the workman was injured in the course of his employment by some risk incident to the employment, he was considered to have assumed the risk and could not recover.

These were the main rules of the common law applicable to employers and their employees. We will now consider them in the light of decisions handed down by the courts in specific cases dealing with the explosion of chemicals.

In an Iowa case, a drug clerk was mixing a compound of explosive nature. He ascended his ladder to get another ingredient, leaving the mixture on the shelf below. The mixture being compounded was explosive only to force or blows. He failed to tell another clerk who was working at a soda fountain of the dangers lurking in the compound. The latter went to the mixture and attempted to stir it. An explosion occurred injuring the latter. He sought damages.

The court held that "No duty which a druggist owes his employees with respect to furnishing a safe place to work is violated by leaving a mixture which is being compounded by an experienced pharmacist and is explosive under a blow or force in an open mortar while the one at work upon it ascends a ladder to secure other chemicals." The court also held that the employer was not guilty of negligence for a failure to warn the clerk at the soda fountain of the dangers attending the mixture.

In a Michigan case, a flashlight mixture was being compounded. The employee stated that, as usual, in preparing the mixture, he mixed together equal parts of powder and magnesium, when in some unaccountable manner the mixture exploded. The evidence tended to disclose the fact that powder and magnesium are not explosive and that the combination of the two when mixed in equal parts was not explosive, that they would not and never had exploded in the experience of the wit-

nesses. The court was of the opinion that some substitute had been used in place of the magnesium and held that it was for the jury to determine. An award had been made by the lower court in favor of the employer, but this decision was reversed.

In a Missouri case, it was claimed that the employer had been guilty of negligence in permitting an employee to put potassium in water during a fire, whereby the explosion resulted, injuring the plaintiff. Said the court: "The plaintiff could not close his eyes upon all that was going on around him or turn a deaf ear to the shouts of danger that went up from the defendant's manager and the bystanders around him, and yet hold the defendant liable because he did not actually see or hear the warning. . . . The instruction should have submitted the issue whether the plaintiff ought to have known the danger in which he was standing, in view of all the facts and circumstances, and not have been confined to what he actually knew, as was done by the one given."

In a New York case, it was shown that a taxidermist employed by the defendant company had poured a mixture of carbon disulphide, a disinfectant, into a bird case, containing electric wires. These wires produced a spark, which ignited the fumes and caused an explosion injuring another who was assisting him. The court held that apart from the statute, the plaintiff had an action at common law for damages.

Among other things, the court said: "It was the plaintiff's duty to assist at the service, and he had used the same material on other occasions, but did not know of the danger of using it in large quantity where there was an electric current, especially running through two twisted wires, the installation of which could be affected by the chemical, so as to permit a short circuit. It was the duty of the employer to know that, and to instruct as to the use of it and warn its agents and employees of the danger. But the plaintiff was committed to the work unwarned. There was a latent danger dependent upon a knowledge of scientific facts, which it was the duty of the employer to have and impart to its servants.

"Although plaintiff had served before in the use of the chemical, here entered a new factor, and as to that a new and more perilous service was introduced and the plaintiff should have been instructed, although he was new only to the increased risk of the service. . . . The manner of use was changed and a new element of danger introduced and yet the plaintiff was unwarned."

Employer Must Warn Workman

In this case, we find the employer being held liable to the employee for the injuries suffered because the employer failed to issue the warnings which his superior knowledge told him, or ought to have told him, should be given to the workman.

In a Missouri case, the workman had been given a can, supposedly empty, but which contained wood alcohol, and was told to solder the tip end of a spout. He attempted to carry out these orders, but when his blow torch came in contact with the alcohol it caused an explosion which caused the injuries complained of. The employer was held guilty of actionable negligence.

In a Massachusetts case, the superintendent of the employing company had a choice of safe and dangerous materials in cleaning out the interior of a boiler, but instructed the plaintiff to use naphtha. The latter attempted to do so, but the fumes came in contact with a lamp which he was carrying, resulting in the explosion, causing the injury complained of. The employer was held not liable, because the court was of the opinion that the superintendent was a fellow servant of the injured workman, and because the danger to which the workman was exposed was merely a transitory one, existing only on the single occasion when the injury was sustained, and due to no fault of plan or construction, or lack of repair, and no permanent defect or want of safety in the defendant's works or in the manner in which they had been ordinarily used.

In a Michigan case, the workman was directed by his employer to help put out a fire and was injured by the explosion of a barrel of paint containing benzine. Judgment was given in the lower court for the plaintiff, but this was reversed, the injuries received being regarded more as an accident than as the result of negligence. The court also held that keeping a barrel of paint on the premises was not negligence, although fire was not improbable. It was not in and of itself dangerous, nor was its presence or its use attended with danger, in the absence of the agency.

The court said: "This is not a case of insecure place or defective appliances, nor is it one where the servant was ordered into another branch of the ordinary service in which there were increased hazards. . . . The dangers ordinarily incident to a fire are obvious to persons of mature years. Employer and employees are equally conscious of such danger, and ordinarily equally skilled in the means employed to extinguish a fire. The work of extinguishment is usually attended with danger, and explosions are not uncommon. The law recognizes a fire as one of the perils which excuse acts otherwise illegal."

In a New York case, the employer directed his servant to thrust his hand into a waste pipe, whereby the hand and the arm of the servant were badly burned by a solution of potash which had been thrown into the pipe without the servant's knowledge and prior to his employment. The court held that the master's order was an assurance that it was safe for the employee to do so, and that the master was chargeable with negligence for not having exercised ordinary care before giving such assurance. The court also said that it was the employer's duty to furnish the servant from the outstart with a place to work in as reasonably safe and free from the risk of injury as the character of the employment would permit, or, before assigning him to work, to call his attention to such lurking dangers as in the exercise of ordinary prudence the former would have been able to discover. The duty was somewhat further intensified, in the opinion of the court, because of the youth and inexperience of the workman.

The employer must not come to the conclusion that these common law principles and decisions are by any means out of date and not applicable to cases to-day. The fact is, as was mentioned before, a great many of the States have not departed from the common law practice in the least particular. Then, in many of the States having workmen's compensation legislation, thousands of workmen are not covered by such legislation. This means that the common law still applies to them in case of injury. Keeping these points in mind will serve to benefit many employers.

Editor's Note: This article is to be continued. Part II will deal with Workmen's Compensation Acts.

Thermo-Electric Pyrometers for Plant Use

BY A. O. ASEMAN

THE most widely used pyrometer for general metallurgical operations is the thermo-electric pyrometer. Its popularity is due in part to its cheapness, robustness, ease of observation, and availability for automatically making a permanent record. It can also be used over a wider range than any other form of pyrometer, giving readings of extreme accuracy from the boiling point of liquid air (— 193 deg. C.) to the melting point of palladium (1550 deg. C.).

In what follows, this pyrometer will be treated strictly from an industrial viewpoint. The following nomenclature for the various parts is now almost universally used. The two unlike wires giving rise to an e.m.f. when heated are known as a thermo-element or thermocouple, or simply couple. The couple, suitably insulated, complete with mounting and protecting tubes, is known as a fire-end. The galvanometer for measuring the e.m.f. developed is known as a millivoltmeter or potentiometer, and may be recording. If this instrument is graduated to read temperature direct, it is known as an indicator. The couple and galvanometer together are called a thermo-electric pyrometer or recording pyrometer as the case may be.

THERMOCOUPLES

Thermocouples are divided into two classes, namely, rare or noble metal, and base metal couples.

Of the rare metal class the Le Chatelier couple, composed of one wire (—) of pure platinum, and the other (+) of an alloy of 90 per cent platinum and 10 per cent rhodium, is the only one in general use. The two chief manufacturers of this couple are Johnson Matthey & Co. of London and Heraeus of Germany. Charles Engelhard of New York is now producing the Heraeus platinum in this country according to the original process. The Johnson Matthey & Co. platinum has a slightly higher thermo-electric power, but is not constant from year to year. The Heraeus platinum has maintained a constant calibration for many years, and is to be recommended of the two. It also exhibits less tendency to crystallize. The 90 Pt-10 Ir couple was popular for some time and is still used in places, as it has about 50 per cent higher thermo-electric power. Its use, however, is not to be recommended, as heating distils the iridium rapidly, thereby changing its calibration. Tests show a change of over 13 per cent from heating at 1100 deg. C. for eight hours.

Of the base metal couples there are a number in general use. These have a higher thermo-electric power, and are cheaper at first cost, but owing to their rapid deterioration, especially at the higher temperatures, it is often cheaper to use the more expensive rare metal couples. The higher thermo-electric power, however (being from four to six times that of the rare metal couples), is a decided advantage, as it permits the use of more robust indicating and recording instruments. The advantage of this for plant use is apparent.

Fig. 1 shows the temperature millivolt relation for the principal types of couples on the market to-day. The upper limit to which these couples can be used continuously is indicated by the termination of the curve. The chromel-alumel couples are useful at higher temperature than any other base metal couple, but are considerably more expensive. The temperature e.m.f. relation for most couples is rather complex, but can be closely approximated by the parabolic formula

$$E = a + bt + ct^2 \qquad (1)$$

or

$$E = ab + bt^2 \qquad (2)$$

In the case of most base metal couples, the curve approaches so closely to a straight line that for all practical purposes a linear equation holds

$$E = a + bt \qquad (3)$$

A couple is calibrated by observing the e.m.f. generated at one or more fixed points, and substituting these values in the corresponding formula and solving in the usual way. A more convenient method is to plot these points graphically and draw a smooth curve fitting all points.

As a general rule a couple should not be exposed directly to a high temperature, on account of its susceptibility to contaminating influences such as reducing gases, metallic vapors, silica, and other agents which al-

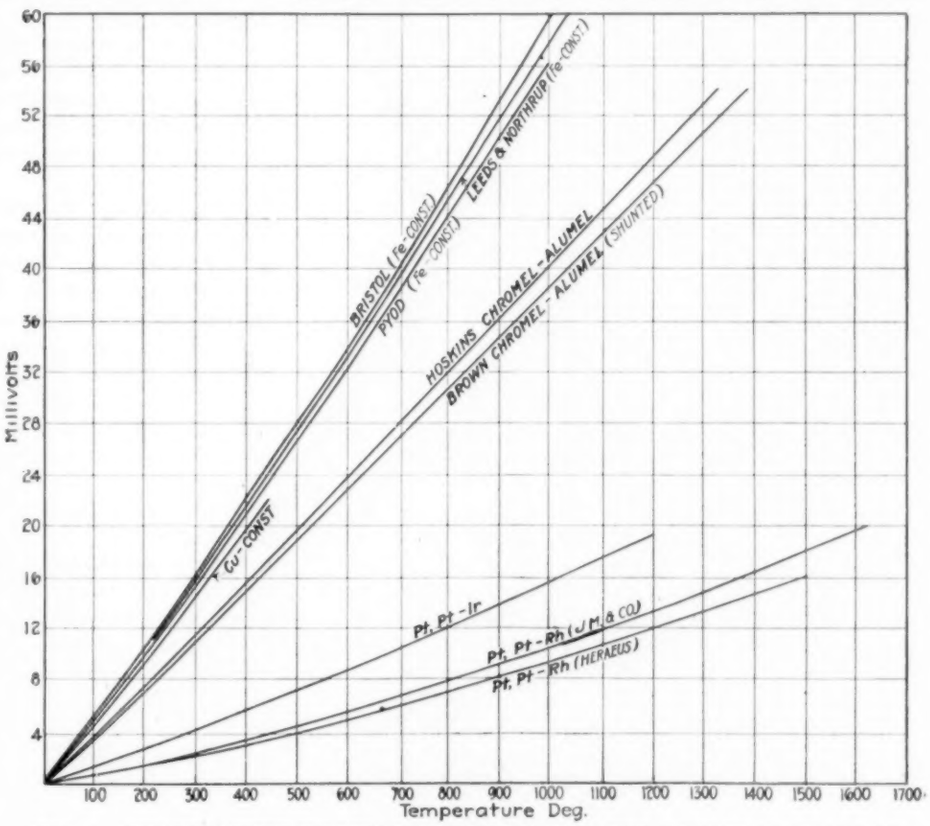


FIG. 1. TEMPERATURE-MILLIVOLT RELATION FOR THE PRINCIPAL TYPES OF COUPLES

ter its thermo-electric characteristics. This is taken care of by enclosing the couple in suitable protecting tubes. Often two protecting tubes are used, distinguished as primary and secondary. The primary protection is impervious to gas and may be either a glazed porcelain, silica or metal tube.

Porcelain is capable of standing a higher temperature, being used above 1200 deg. C. under constant temperature conditions. The porcelain available now has such a high temperature coefficient that it will not stand up under varying temperature. It has recently been announced that a pyrometer maker in this country has succeeded in making porcelain pyrometer tubes with a much lower coefficient of expansion, but up to the time of writing this we have been unable to try them out.

Silica can be used continuously up to 1100 deg. C. or for a short time to higher temperatures. At 1200 deg. C. or higher it devitrifies rapidly, becoming porous and losing its mechanical strength. Metal sheaths are usually of iron or steel, the properties of which are too well known to need special mention.

The secondary protection is used to give mechanical strength to the fire-end or to protect the primary from the action of corrosive vapors or metals. Zinc vapor is especially corrosive in porcelain. The materials most commonly used are fire clay, nickel chromium alloys, calorized steel or carborundum tubes.

The best manner of insulating the two wires is by means of a double bored insulating tube. This is very desirable when silica protecting tubes are used, as it is important that the wires (especially rare metal wires) do not come in contact with the silica.

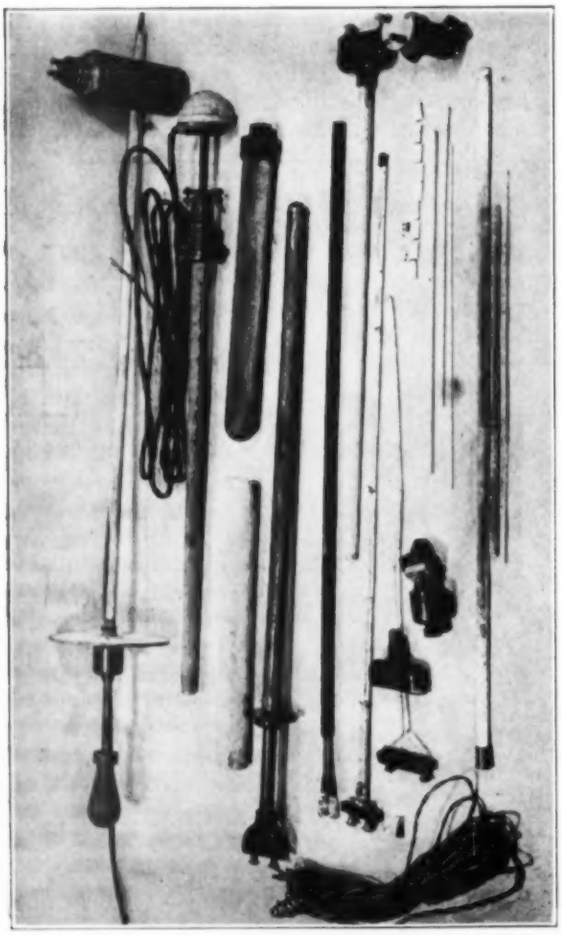


FIG. 2

Forms of portable and permanent mountings, primary and secondary protecting tubes, insulating tubes, cold junction extension wire, and water cooled cold junction devices.

It is desirable for plant use to mount the couple so that it, with its protecting tubes, will be firmly held together. This is usually done with suitable pipe fittings. Fig. 2 shows several forms of mountings with various accessories for portable and permanent use.

GALVANOMETERS

The question of the instrument for reading the couple e.m.f. is one which deserves considerable thought. The tendency in instrument construction of the galvanometer type is to make as high a resistance as is consistent with making it sufficiently robust to stand up under plant usage. Instruments of this type are connected ammeter-like in series with the thermocouple. The thermo-electric current generated is small and is affected by any change in the resistance of the circuit. By using high-resistance instruments the change in the external circuit is a small part of the total resistance. Thus take the case of two galvanometers, one with an internal resistance of 5 ohms and one of 300 ohms, both calibrated to read correct for an external resistance of 2 ohms. Suppose that in each case the external resistance is increased by 0.8 ohm by changing the depth of immersion of the couple, or increasing the length of leads. The error due to the external resistance is equal to the resistance of the galvanometer plus the fixed external resistance, divided by the sum of the total resistance of the circuit.

$$\text{Then } \frac{300 + 2}{300 + 2 + 0.8} = 0.997 \text{ or } - 0.3 \text{ of 1 per cent}$$

$$\text{and } \frac{5 + 2}{5 + 2 + 0.8} = 0.897 \text{ or } - 10.3 \text{ per cent.}$$

A change of 0.8 ohm in the case of the 300-ohm instrument is quite negligible, while in the case of the 5-ohm instrument it is far from so, even for rough work. These are not exaggerated cases, but are constantly met with in everyday practice. It is quite evident, then, that the use of low-resistance instruments should be discouraged.

In an attempt to eliminate the effects of a variable external resistance, such instruments as the portable potentiometer and pyrovolter have been developed. The readings of these instruments are independent of the external resistance. They are excellent instruments and recommended for use wherever possible. They are, however, open to the objection that they do not give continuous indications, and require a certain skill to operate. Also they cannot conveniently be made recording. There is a recording potentiometer on the market, but it is more of a laboratory than plant instrument. The readings of a potentiometer cannot be relied on in extreme weather.

Special mention may be made of the Engelhard double suspension instrument and the Wilson-Maeulen unipivot instrument, both embodying features not found in ordinary galvanometer millivoltmeters. The former has no pivots, the moving coil being suspended by two delicate ribbons under tension. This has an extremely high resistance, but has the disadvantage of a shifting zero every time the position of the instrument is changed. It is also very susceptible to vibrations. The unipivot instrument has, as the name implies, only one pivot, which is at the center of gravity of the moving element. This is a very robust instrument, and is the

only one on the market for portable use in which the pivot can be removed from the jewel while transporting from place to place. This is a valuable feature, as it has been our experience that these instruments are usually damaged while being ported about rather than when in use. It is evident that, although the weight of a moving element is small, when the entire weight is concentrated on a point there may be a pressure of several thousand pounds per square inch, in which case it does not require a very hard jolt to puncture the jewel. Of course most instruments are magnetically damped, but this only prevents rotation, and does not prevent the harmful sudden stresses on the jewels.

Cold Junction

Attention should be called to the cold junction correction, since there is a notable tendency to neglect this important consideration. The e.m.f. developed by a couple depends on the difference in temperature between the hot and cold junctions, as well as the actual temperature of each. In calibrating a couple, therefore, the cold junction is maintained at some definite temperature, usually 0 deg. C. In practice it is ofttimes convenient to maintain the cold junction at a temperature other than that at which the couple has been calibrated, in which case the reading must be modified by a "cold junction correction." The correction is equal to the change in temperature multiplied by a factor.

$$\text{Cor.} = (t_1 - t_0)\ K \qquad (4)$$

t_1 = operating temperature of cold junction
t_0 = calibration temperature of cold junction (0 deg. C.)
K = factor depending on couple.

If the indications are obtained in millivolts, it is only necessary to add to the observed e.m.f. the value of the e.m.f. developed when the cold junction is at 0 deg. C. and the hot junction is at t_1 deg. If the indications are obtained in degrees, the correction must be made in degrees. For a Pt, Pt-Rh thermocouple, K, in formula (4) is 0.6 when hot junction is from 400 to 700 deg. and 0.5 when hot junction is between 700 and 1400 deg. C. In the case of base metal couples, the calibration curve of which is approximately a straight line, K is equal to 1.0.

A number of schemes and devices have appeared for keeping the cold junction temperature constant, or automatically compensating for same. One convenient method is by use of cold junction extension leads, whereby the junction can be removed to a region of more uniform temperature. These leads may or may not be of the same material as the couple, but they do have the same thermo-electric characteristics as the couple. In permanent installations one method is to bury the cold junction by driving a pipe pointed at one end 10 to 12 ft. in the ground, at which point the temperature remains constant throughout the year. Another plan is to water-cool the cold junction by means of running water. Still another is to lead the cold junction to a thermostatic controlled constant temperature box. There are numerous other devices, each having certain advantages and disadvantages. The methods described above merely keep the cold junction temperature constant. Those which compensate for a changing temperature are complicated, delicate and very likely to get out of order, so their use should be avoided.

Calibrations of thermocouples are spoken of as primary and secondary. Primary calibrations are made by noting the e.m.f. generated by a couple immersed in a pure substance, when at its melting point. Observations taken at regular time intervals show no change in temperature while the substance is melting. The melting point, which is very accurately known, serves as a fixed point at which couple e.m.f. can be read. Some of the commonly used fixed points are:

	deg. C.
Melting point of ice	0
Melting point of tin	232
Melting point of zinc	419
Melting point of salt (NaCl)	801

To calibrate a couple, then, it is necessary to observe the e.m.f. generated when the hot junction is exposed to the melting point temperatures of several of the above fixed points. A calibration curve can then be made by plotting the known melting temperatures as ordinates, and the corresponding e.m.f. in millivolts as abscissas, as in Fig. 1.

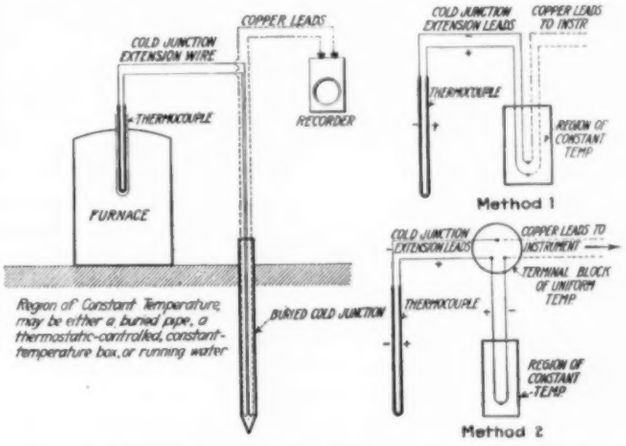


FIG. 3. METHODS OF MAINTAINING COLD JUNCTION AT CONSTANT TEMPERATURE

By use of calibration curves similar to those shown in Fig. 1, it is possible to completely calibrate a couple, by simply taking a zinc point, and plotting this point with the corresponding curve for that couple. A curve drawn through the point and having the same shape as the standard curve will be the calibration of the couple.

The zinc point may be taken in the following manner: A crucible is made from a piece of 2-in. wrought iron pipe 8 to 10 in. long with a cap on one end. This is filled with "Horsehead" zinc and melted, and the couple, suitably protected, immersed in it. The whole is then allowed to cool, and readings made every half minute. The freezing point is taken when the couple indication does not change perceptibly over a period of 5 to 10 or more readings. It is best to protect the couple by a closed steel tube. Porcelain should never be directly exposed to molten or vaporized zinc.

Secondary calibrations are made by comparing the couple to another which has already been calibrated by primary calibration. This is best done by enclosing both couples, suitably insulated, in an iron pipe and heating the pipe in a furnace. Indications of both couples can be made on the same instrument by means of a double throw switch.

Generally speaking, it is better when possible to have calibrations made in a laboratory equipped for that purpose. All couples and instruments should be checked frequently.

Research Department,
New Jersey Zinc Co.

Manufacturing Plant of the Providence Gas Co.—II*

Description of the Installation and Operation of the New Water Gas and Producer Gas Plants at Sassafras Point—Water and Producer Gas Machinery and Apparatus, Measuring and Recording Instruments

By WALTER M. RUSSELL

IN THE water gas plant three 11-ft. 6-in. U.G.I. standard carbureted water gas machines were installed. (Fig. 9.)

Air for blasting is provided individually for each machine, but by means of a manifold any one of the three blowers may serve the machines. In routine operations, one blower serves one machine only. The blowers were furnished by the Rateau-Battu-Smoot Co. and consist of standard Rateau steam turbines, each driving two birotor blowers, there being two impellers within a single casing acting in parallel, the inlet and discharge connections being connected in parallel with a single orifice in each case. The radial impeller blades are dovetailed into a heavy steel shaft. Volutes feed suction air to the impellers and after leaving the impellers the air enters the diffusion chamber, wherein discharge velocity is converted into pressure. The blower casing is parted on the horizontal center line. inlet and outlet nozzles being located in the lower half. These blowers operate at comparatively high speed—about 7500 r.p.m.—and, as the blower shaft is so designed as not to pass through its critical speed, the blowers may be stopped and started at frequent intervals, it being possible to bring them from rest to full speed in 10 sec. after having been heated up. Because of the high speed, great care had to be taken in designing the lubrication. The bearings are amply large and are provided with oil rings and water cooled chambers.

The steam expands in the stationary nozzles and drives the rotary element on a single row of buckets. The pressure of air is maintained by means of a constant pressure regulator, which acts directly on the steam, being adjusted for any given air pressure by a weight sliding on a lever arm. These turbo blowers have been highly satisfactory. At 140-lb. steam pressure, they have delivered 20,000 cu.ft. of air per min. through a 20-in. pipe with 36-in. pressure at the Venturi meter. Such apparatus must be given more care than is usually given to blast equipment for water gas sets.

The stack valve, up-and-down run valve, steam valve, secondary and primary blast gates are all handled by hydraulic valves. These hydraulic valves are controlled by a group of levers set together at a convenient place for the operator of the machine. The action of these valves is extremely smooth and satisfactory and has made the labor of operating the machines very light compared to the old fashioned manner of working.

During the period of blowing, the amount of secondary air required to make perfect combustion at the stack must constantly be increased, and to maintain this condition, an automatic device is made use of. This device consists of a small gas holder, which is filled during the blow by the air pressure from the main blast line. As this little holder gradually rises, it automatically increases the flow of air to the carbureter and, by means of simple adjustments, the right amount of air is admitted during each minute of the run to secure complete combustion of the carbon monoxide generated.

Venturi meters are used for measuring the flow of air to the generators during the blow. The pressure indication of the meters is transmitted to a water column on the gageboard of the machine, this column having a graduated scale, from which may be read the amount of air in cubic feet passing the fire per minute.

Venturi meters are also used for measuring the upsteam and down-steam used during the gas making period. The meters are equipped with indicating dials, which show directly the number of pounds of steam entering the fire per minute of run.

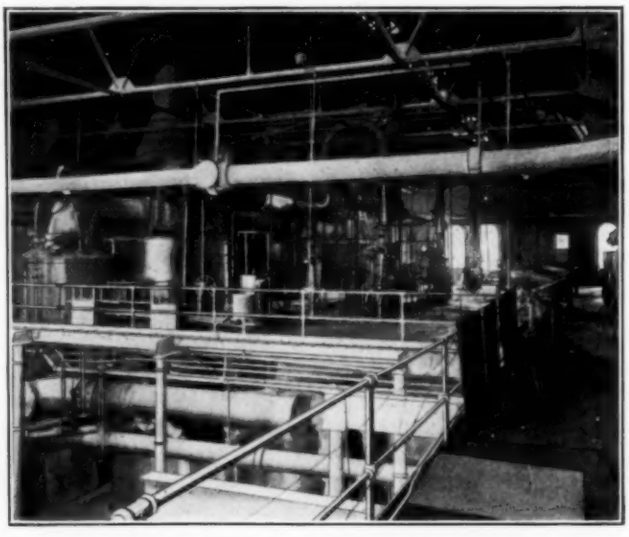


FIG. 9. GENERATOR HOUSE OPERATING FLOOR

To indicate the temperature at the top and bottom of the superheater, Bristol indicating pyrometers were originally installed. During the last year, on account of the poor oil and fuel which were obtainable, much more careful operation of the machines was demanded and Thwing recording pyrometers were installed, which made a record of the temperature at three points, namely: the middle of the carbureter and top and bottom of the superheater. These instruments are installed in a little dust-proof room just off the operating floor and have given great satisfaction.

A gageboard is provided for the use of the operator of the machines, located in a convenient place for his observation. On this board are placed gages showing the pressure of the blast air and, during the run, of the pressure under the grate and the pressure leaving the

*Read before the American Institute of Chemical Engineers, Cambridge, Mass., June 20, 1919. Part I published in CHEM. & MET. ENGNG., Vol. 21, No. 1, July 1, 1919, p. 34.

FIG. 10. TAR EXTRACTOR AND WASHER

machine. On the upper part of the gageboard is a gas maker's clock with a very conspicious second hand, two dials, indicating, respectively, the amount of steam used on up-runs and down-runs, and a graduated gage glass for indicating the amount of air passing through the generator during the blow and a gage indicating the pressure of oil in the line going to the sprays. Back of the gageboard and in a convenient location is the battery of levers which control the operation of the hydraulic valves used in handling the various parts of the machine. There is also a meter for measuring the amount of oil admitted to the machine during each run. On the wall directly back of this bank of valves is an indicating pyrometer. It will be seen that great care has been taken to make the work of the operator convenient and easy, and it is possible to secure a very high degree of efficiency by such an arrangement.

The general design of these water gas machines does not depart from the standard American Lowe carbureted water gas plant as developed by the United Gas Improvement Co. and embodies those details of construction and operation which have proved themselves by many years of successful operation.

Coal or coke for use in the generators is delivered by means of chutes from the outside bins to trucks or buggies on the operating floor. These buggies hold about 3600 lb. of coal and are drawn over scales for weighing before discharging their contents into the generators.

The washer tar batter is a recent development of the United Gas Improvement Co. and it takes the place of the seal pot and tray scrubbers usually employed. It is set upon the operating floor at the side of the extended superheater with a short connector from it and consists of a steel plate shell with an internal divided flow dip pipe. Water, tar and foreign matter are removed by impingement on baffles as the gas passes through. In addition to its scrubbing action, the back pressure, during the gas-making period, is less with this type of apparatus, owing to the greatly increased perimeter of the 4-way pipe over that of a single dip pipe. This apparatus has given no trouble and has been uniformly successful in its operation.

Gas Main and Relief Holder—Leaving the seal pots, the gas enters a 36-in. outside overhead main, which carries the gas to the relief holder. This main is made of riveted steel pipe and is supported on steel trusses. The relief holder is of 500,000 cu.ft. capacity, in two lifts, in a steel tank, and is of the Bartlett Hayward standard style of construction.

Condensers—Gas is drawn by means of exhausters from the relief holder through a battery of two outdoor water tube condensers. These condensers are rectangular in form and have seven compartments, gas passing from one compartment to the next and being made to impinge upon the tubes by means of baffle plates. These condensers are constructed of cast iron, which permits the use of salt water from the bay. The temperature of the gas leaving the condensers is regulated by means of a Tagliabue control apparatus acting on the main water lines. Two pumps are provided for handling the salt water to the condensers, one of which is a spare. Both are centrifugal pumps, one being motor driven and the other operated by a steam turbine. From each compartment of the condensers a tar drain connects to a common tar main, which delivers tar and condensed water to the general drip system of the water gas plant.

Exhausters and Pumps—Two No. 10 Roots gas exhausters were brought from the South Station and set up in a new engine room. These exhausters have been driven at the rate of 400,000 cu.ft. of gas per hr. each, which is equal to the largest demand which has yet been placed upon the plant. During the past year, considerable trouble was experienced with the engines, owing to there being a rigid coupling between the exhauster and the engine, and this rigid coupling was replaced by rope couplings, which have given great satisfaction.

In the pump pit in the north end of the engine room are located seven Simplex pumps, which serve the general yard drips, circulating water to the submersion washer, washer tar batters, tar tanks, and oil supply from the oil tanks to the water gas machines.

Each pump is equipped with a constant pressure regulator and the oil pumps have, in addition, a by-pass relief valve, so that a very uniform pressure is maintained in the oil line.

Tar Extractor and Submersion Washer—After leaving the exhauster, the gas passes underground to the P. & A. house, where it first enters a submersion wash-

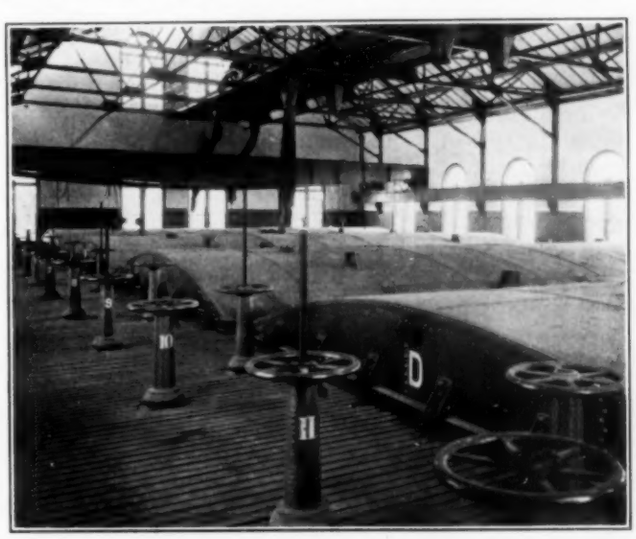


FIG. 11. WATER GAS PURIFIERS, SHOWING COVERS, BELT CONVEYOR AND CRANE

er supplied by the Western Gas Construction Co. This washer operates at a differential of about 2½-in. at full load and is fed with a small stream of warm water from the tar separators. This washer is built in two sections, one above the other. (Fig. 10.)

Following the submersion washer is a P. & A. tar extractor, designed and built particularly for water gas tar extraction by the Gas Machinery Co., Cleveland, Ohio. This extractor consists of a steel plate shell, housing a series of concentric slotted metal drums. This extractor operates at a differential of about 7-in.

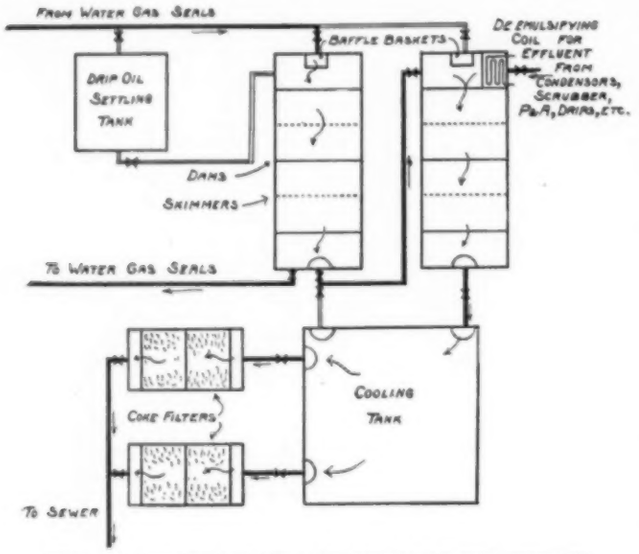


FIG. 12. DIAGRAM OF TAR SEPARATING SYSTEM

under full load. The capacity of the tar extractor plant is in the neighborhood of 10,000,000 cu.ft. per day and the plant has been satisfactory in every respect.

Purifiers—From the tar extraction apparatus, a 30-in. underground cast iron main runs to the purifying house —a distance of approximately 700 ft. There are four purifiers, 45 ft. by 25 ft. by 12 ft. (Fig. 11.) The four boxes are set in a line, connected on long sides by means of common partitions. The sides and bottoms of the boxes are constructed entirely of steel with riveted joints. The inlet and outlet connections are 24 in. in diameter. Each box is provided with two layers of tray supporting beams and two layers of oxide have been used, although provision was made for four tiers, if desired. The valve connections are so designed as to permit of passing the gas through the oxide from top to bottom or from bottom to top and also the boxes may be operated in forward or backward rotation.

To the bottom of each purifier are attached six oxide dumps, 20 in. in diameter, provided with self-sealing lids. The covers are of steel and are trunk shaped, reinforced by means of steel lattice girders located on the inside of the covers. The sides of the covers are formed of a heavy curved angle, which engages with an asbestos lute carried on the frame of the box. The covers are provided with holding-down clamps spaced about 40 in., center to center, designed to withstand a pressure of 36 in. of gas and any additional load due to tightness of the clamps.

The purifiers are supported upon steel beams, girders and "H" columns. For handling the purifier covers a traveling crane was provided operated by man hoists. In filling boxes, oxide is dumped from wagons or wheelbarrows into a bucket conveyor, which transfers the oxide to the top of the building, dumping into a belt conveyor, located at the bottom chord of roof truss and extending the entire length of the building. The conveyor was provided with a tripper for discharging the oxide to either of the four sets of filling spouts located above the boxes. This apparatus is motor driven.

Meters—From the purifying house, the gas passes underground to the meter house. When the meter house was built, space was provided for four meters, only one being originally installed for coal gas. At the time of constructing the water gas plant, a 12-ft. and a 14-ft. Tufts meter with Hinman drums were removed from the South Station and re-erected in the present meter house, the gas passing through these two meters in parallel, thence passing to the mixing mains, where the coal gas and water gas were brought together and sent to the distribution holders.

Storage Tanks—One 500,000-gal. steel plate tank was removed from the South Station and two others were erected on concrete foundations over piling. Two tanks have been used for the storage of water gas oil and one for water gas tar. These tanks give a gravity flow to the oil and tar pumps. Oil is received by barges from an oil depot on the other side of the bay and is pumped from the barges into the oil tank.

Tar Separators—The experience with tar separators has been somewhat unusual and has many points of interest. As originally laid out, the tar separating plant consisted of a reinforced concrete settling tank, 20 ft. by 15 ft. by 8 ft. deep, and two separating tanks, 60 ft. by 25 ft. by 7 ft. deep, followed by a cooling tank 52 ft. square and carrying about 6 ft. depth of liquor, the liquor finally passing through two coke filters and discharging into the bay. The tar and water from the generator house, after passing through the seal pots on the machines, first entered the settling tank and then passed into a common header, which also received the tar and condensation from the other parts of the water gas plant. It then passed in parallel through the two separating tanks, thence to the cooling tank and from here the water recirculated through the various pieces of apparatus. This apparatus was never very satisfactory and did not give complete separation of tar from water. In addition, settling took place, so

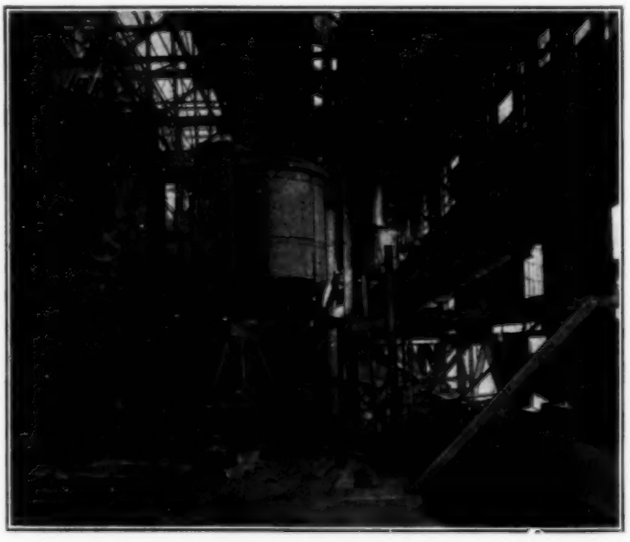


FIG. 13. GAS PRODUCERS AND ACCESSORIES

that the tanks cracked and leaked. In the summer of 1918, these tanks were waterproofed by means of a combination tar paper, pitch and sheet metal covering with a layer of concreting to hold and protect the waterproofing. This rendered the tanks waterproof and any further settlement is not feared. After studying the behavior of our tar and water emulsions, the following system was finally adopted: The first settling tank was abandoned, as apparently it served no useful purpose. The liquor from the wash boxes in the generator house was caused to pass into the first or right hand settling tank and double the original number of dams and baffles were provided, so that twice the separating effect was secured. The depth of liquor in the tanks was also increased about 15 per cent. The overflow from this tank, instead of going to the cooling pond, returned to the left hand or second separating tank.

The effluent from the tar extracting apparatus, condenser, exhauster house drips, etc., passed into a demulsifying chamber located at the entrance end of the second or left-hand separator, where it passed over a series of steam-heated pipe coils, thence discharging into the separator, where it mingled with the liquor coming from separating tank No. 1. The number of baffles and dams was also doubled in this second separator and the overflow from it went to the cooling tank and thence through the coke filters to the bay. The water for circulation through the wash box, etc., instead of being taken from the cooling tank, was taken from the end or separating tank No. 1. It will readily be seen that several improvements have been made. The length of travel has been doubled by placing the separating tanks in series instead of in parallel and, in addition to this, the separating effect in each tank has been doubled by doubling the number of baffles. Furthermore, inasmuch as the circulating water is now taken from No. 1 separating tank, the flow through the second separating tank is greatly diminished, as the volume of material to be handled is very much less than if the circulating water was taken from the outlet end of the whole system. The system as finally adopted has worked with great satisfaction, although, due to the forced employment of an inferior grade of oil during the past year, it has not been possible to secure water gas tar having a low moisture content, but the separation of tar from the circulating water is practically perfect.

The accompanying illustration (Fig. 12) shows the general layout of this apparatus. We are now using the first settling tank for storage of drip oil, etc., which we use in our boilers. The black solid lines show the flow of tar and water as now operated. The double lines show the original connections, which are not now in use. As is very well known, during the early part of the year 1918 there was a great shortage and demand for all products of ammonia. This fact was well recognized by the engineers of the gas company and influenced them in deciding upon by-product recovery producers. After the order had been given for the producers and before the details of the cleaning and ammonia extraction plant were worked out, this demand ceased and the original plans were not carried out. The plant as it is now, therefore, consists of by-product producers which may be operated either with or without by-product recovery and a set of apparatus for cleaning and cooling the gas, which has been considerably modified and simplified from the original design, although the plant could readily be converted for ammonia recovery, should it so be desired at any time in the future.

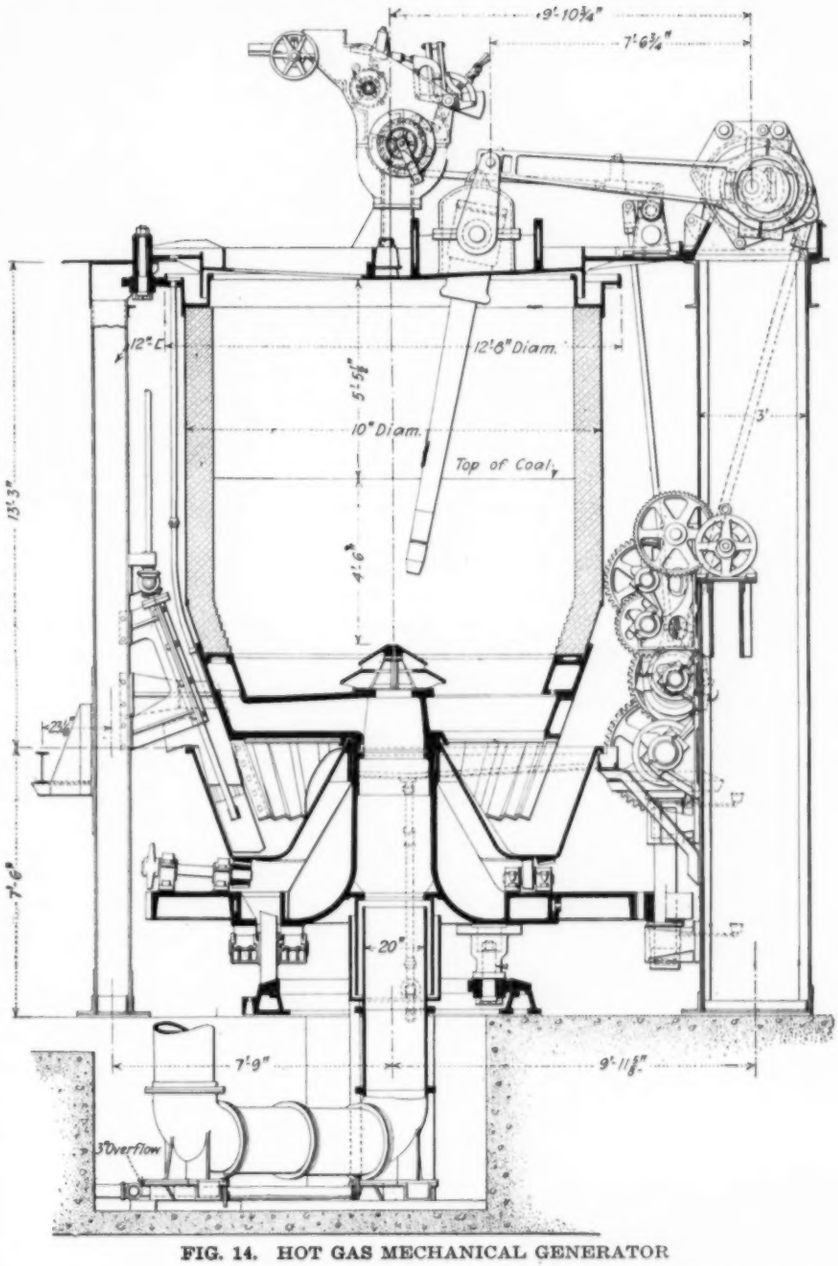


FIG. 14. HOT GAS MECHANICAL GENERATOR

Gas Producers—The gas producers are five in number and were built by the Wellman-Seaver-Morgan Co. They are designed to produce gas from bituminous coal

either with or without recovery of ammonia; or to produce gas from coke. Generally speaking, these producers are a modified form of the standard Hughes producer, the principal difference being in the maximum depth of fuel possible and the massive size of the machinery column, stirring mechanism, etc. (Fig. 13.)

In a casual observation, an engineer familiar with gas producers is immediately struck by the great height of this apparatus. The distance from the floor line to the top of the producer is 20 ft. 9 in.: from the top of the air inlet or tuyere in the lower part of the producer to the under side of the top, 10 ft., which would allow a fuel bed of 8 or 9 ft. in depth, including the ash and clinker zone. The inside diameter of the steel shell of the producer is 11 ft. 6 in. and there is a 9-in. firebrick lining, which reduces the diameter to 10 feet. (Fig. 14.)

When operating for plain gas production, the producer shell is rotated at a speed of one revolution in ten minutes. If it is desired to operate for by-product recovery, this speed will be cut in half. The ash pan is free to revolve independently of the shell but, owing to the presence of ashes in the pan, it revolves with the shell, due to the binding action of the wet ashes. In order to keep the ash bed and lowest zone of the producer in a free condition, it is arranged to have this ash pan take an intermittent retrograde movement with reference to the producer shell. This is secured by means of two trippers set at 180 deg. apart, which, by striking a stop, cause the ash pan to rotate for a few inches in a direction opposite to the rotation of the producer shell.

Coal is fed to the producer from an overhead coal bin by means of a gas-tight measuring feeder, which is operated by the motor driving the rest of the producer mechanism and can be adjusted through a wide range of speed in feeding. For stirring the fuel bed, a long poker is provided, which is dragged through the fire in a direction approximately at right angles to the direction of rotation. On No. 1 producer there are two pokers—a long and a short—which would be used in all the producers should they be operated for by-product recovery with a deep fuel bed. When using a deep fuel bed, the long poker stirs the zone just above the ashes and the short poker penetrates about 2 ft. below the top of the coal. The other producers are equipped with a single poker only, but the poker shaft is arranged to take the second short poker at any time desired in the future. (Fig. 15.)

These producers are blown with air saturated with steam, the air being furnished by Coppus steam turbine blowers at pressures running from 8 in. to 24 in., depending on the depth of fuel, depth of ash zone and other conditions. The exhaust steam from these blowers goes into the blast air and additional steam is also admitted under careful control, so that the temperature

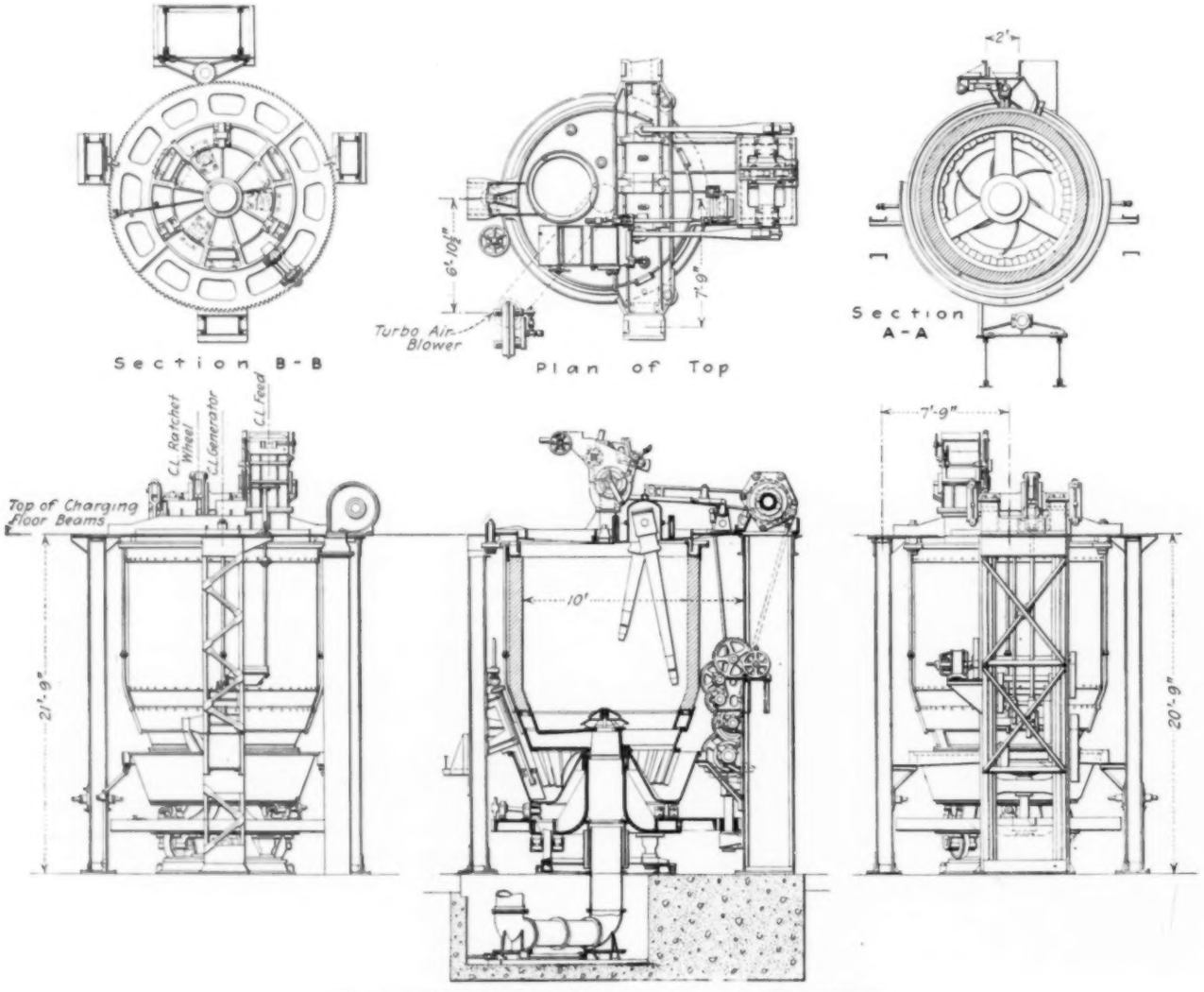


FIG. 15. BY-PRODUCT MECHANICAL GAS GENERATOR

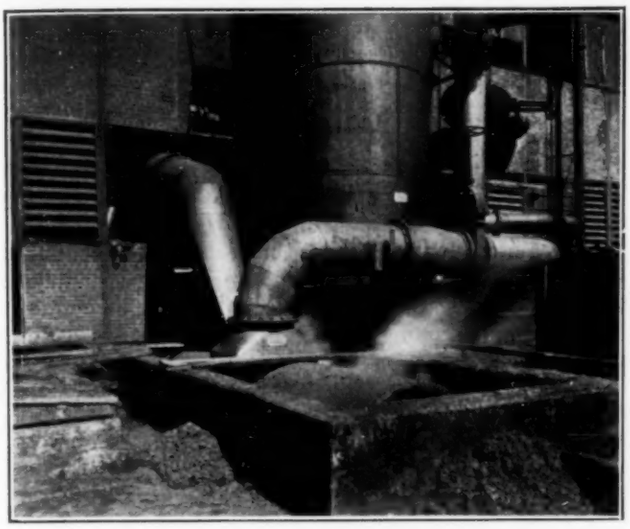


FIG. 16. BARBOTAGE AND WASHER COOLER

of the blast air is an indication of the amount of steam being used. This temperature may be 140 to 150 deg. F. more or less, depending upon the conditions, and this represents something like 1.2 lb. of steam per lb. of coal gasified.

Air is admitted to the center of the producer through a double headed tuyere, and also by means of a hollow spider the air is admitted at the sides of the producer in order to obtain an even distribution of air. The producer house is arranged for six producers, and should the plant operate for ammonia recovery, it is probable that six would be needed, five only being installed at the present time, which it is felt is ample for the heating of the forty coke ovens operating on 15-hr. coking time, running four producers with one idle for cleaning or repairs.

Roughly speaking, about 100 tons of bituminous coal of good quality must be gasified to heat the battery when in full operation. If ammonia recovery is practiced, probably not over 20 tons of coal will be gasified per producer per day. On the other hand, when operating with a shallow fuel bed without recovery of by-products, it is believed that three producers are entirely sufficent, inasmuch as 35 tons of coal have been successfully gasified in one producer in 24 hours.

In the first weeks of operation it was found that the heating value of the gas varied from 135 to 175 B.t.u., depending on depth of fuel, amount of steam, blast pressure, etc.

The oven battery is so designed that all or any part of the battery may be heated with producer gas, and a great deal of experimental work has been done in determining the range and capacity of the different parts of the producer gas plant by varying the number of ovens heated from one producer and also varying the coking time; thus demonstrating the extremely flexible arrangement of the combined producer gas and run of oven gas system for heating the coke ovens.

Gas Treatment—The preparation of the gas for use in the coke ovens requires removal of dust, pitch, tar and a large portion of the moisture and heat, the maximum desirable temperature at the outlet of the fuel gas holder being in the neighborhood of 100 deg. F. This problem was given to the Steere Engineering Co. of Detroit, who designed, built and installed all of the cleaning apparatus, acting also as engineers and erectors on the producer gas plant as a whole. The major portion of the apparatus was designed in line with the standard practice of the Steere Engineering Co. for clean producer gas plants, several improved and new features being introduced.

Dust Catcher—The gas leaving the producer has a temperature of 1100 to 1300 deg. F. and is laden with coal dust, soot and pitch. It first enters a dust catcher (one of which is provided for each producer), where a sharp and sudden change in the direction of the gas is caused, precipitating the dust to the bottom of the dust catcher. To accelerate this action, a heavy spray of hot water enters the dust catcher and strikes the inner cone, dropping thence to the bottom and washing out dust, etc., into a concrete separator.

Each dust catcher discharges its gas into a common collection main running the entire length of the battery of producers. In this main the gas is also heavily sprayed with hot water, the overflow running to the concrete decanter or separator. The gas issues from the collection main at a temperature of 165 to 175 deg. F.

Barbotage—From the collection main the gas enters the barbotage, which is a long rectangular steel box open at the bottom and sealed in the water in the decanter. (Fig. 16.) Inside of this box is another steel box with swinging sides, having serrated edges, the serrations dipping into the water. The gas comes into the inner box and is wire drawn over the surface of the water through the serrations. These swinging sides are balanced by weights and the differential through this apparatus remains the same when changes in the amount of gas passing occur, as, when the gas flow increases, the balanced vanes are blown outward, thereby opening a larger space for the gas to pass through in the serrations but maintaining the same relative action. On the other hand, if the gas flow diminishes, the swinging vanes come inward, decreasing the opening in the V-shaped serrations and again adjusting the wire-drawn effect to accommodate the amount of gas passing.

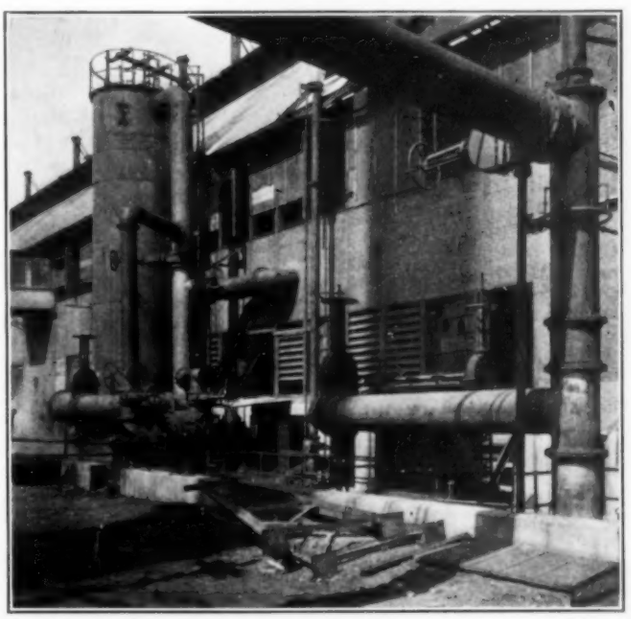


FIG. 17. WASHER COOLER, TAR BEATER, SEPARATOR AND DECANTER

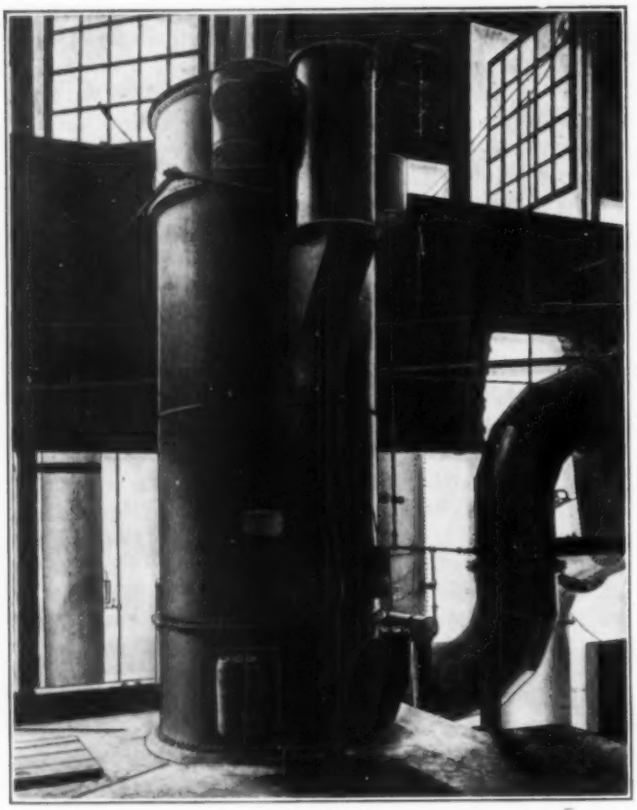


FIG. 18. IONIZER

The barbotage is equipped with sprays for use when necessary. At times dust accumulates on the surface of the water and interferes with the washing effect, and these sprays will drive this accumulation of dust down to the bottom of the decanter.

Washer Cooler—The gas has now been freed from excessive heat, dust and a large portion of the soot. Very little pitch has been removed, and this, together with the light and heavy tar and finely divided free carbon and dust, is still present. To remove a portion of these impurities and to prepare the gas for further treatment, the gas passes through a washer cooler, which is an upright steel shell filled with wooden grids, the gas passing up through the grids, which are heavily sprayed with cold water. (Fig. 17.) This is an exceedingly efficient method of cooling gas and also of removing impurities. The gas leaves the washer cooler at a temperature of about 105 deg. The water enters at about 95 deg. and is brought to a high temperature in passing through the washer cooler, which discharges into the general decanter which extends beneath all the cleaning apparatus.

Tar Batter and Ionizer—For the removal of finely divided pitch globules, heavy and light tars and very fine dust, a combination of centrifugal batting and electrical treatment is used. The gas first enters the tar batter, which is an apparatus something like an enclosed fan, which revolves at 1700 r.p.m. and is supplied with a spray of warm water. The centrifugal action on the gas serves to throw off all the large globules of pitch and heavy tar and the tar and pitch which is not thrown out and washed away by the spray is disintegrated into an extremely fine state. It then passes into the ionizer, which consists of a cylindrical shell containing a series of parallel tubes, each tube having at approximately its center a wire carrying electrical charge of alternating current with a potential of about 17,000 volts. Passing through this electrically charged atmosphere, the finely divided globules of tar and pitch are coagulated and coalesced and driven against the walls of the tubes running down into the bottom of the apparatus and going thence to the decanter. The jacket temperature of the ionizer is maintained at about 140 deg. F., which serves to keep the tar and pitch reasonably fluid, so that it will not build up on the tubes. The temperature of the gas passing through the ionizer in maintained at about 100 deg. F.

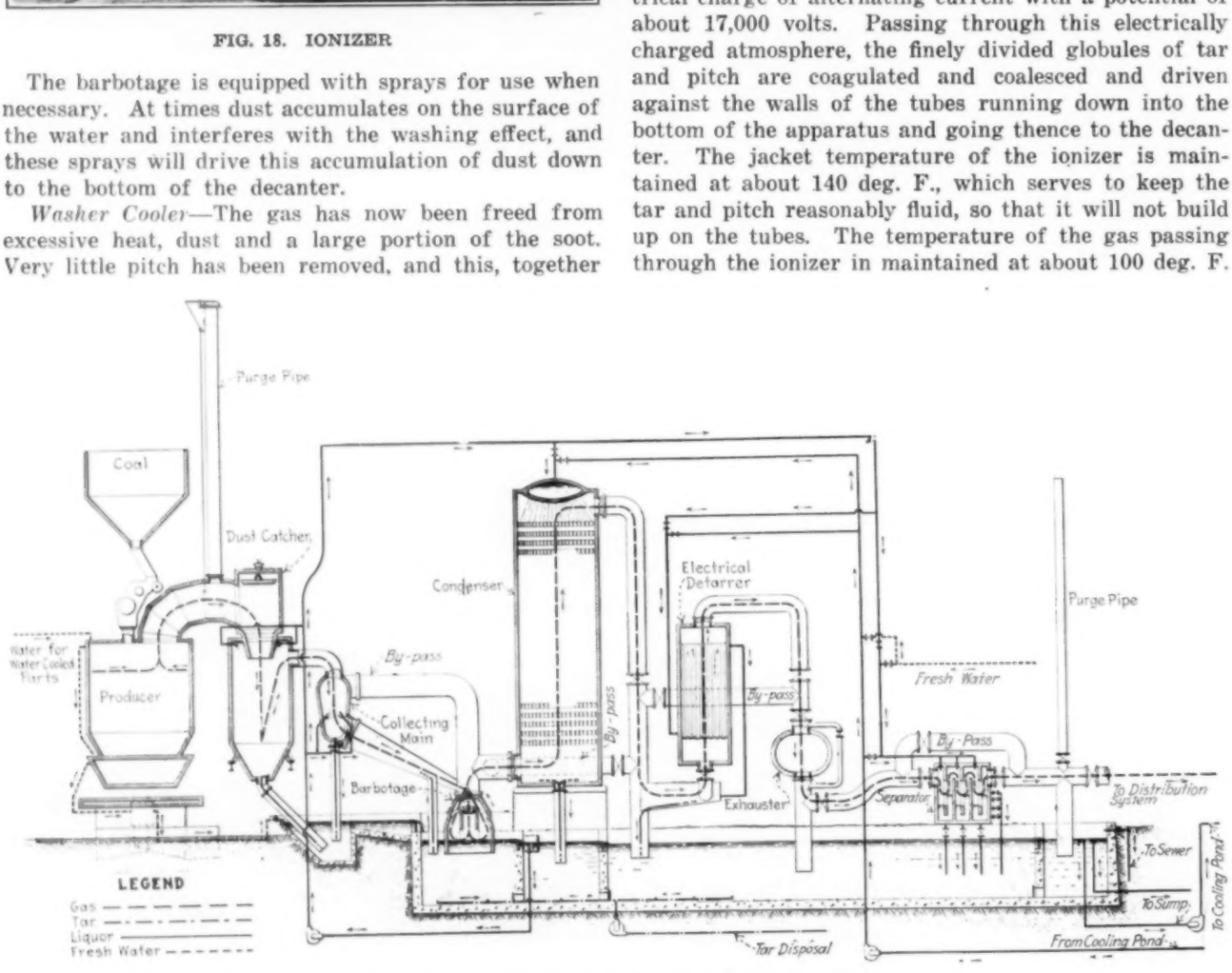


FIG. 19. DIAGRAM OF TAR SEPARATING PROCESS

(Fig. 18.) After leaving the ionizer, the gas goes to two exhausters built by the Connersville Blower Co. and driven by vertical steam engines. These exhausters are automatically governed to maintain a very slight pressure just above the fire in the producers and force the gas through the rest of the cleaning apparatus over into the fuel gas holder. The temperature of the gas leaving the exhausters is about 105 deg. F.

Tar Separator—In the natural course of operating the plant, there are times when various portions of the plant must be by-passed for various reasons, which would permit some tar and dust to be present when leaving the exhausters. To take care of such emergency conditions or overloads, a tar separator was installed, which consists of a rectangular steel box, containing three sets of slotted plates with a backing plate behind each slot. The gas in passing through these knife edge slots is drawn into an exceedingly thin ribbon with high velocity, which, striking against the backing plate, is sharply deflected. This drawing action, combined with the sudden change of direction and further assisted by a spray of cold water which passes down the length of the slot, serves to remove traces of impurities which may be present at this point. After leaving the tar separator, the gas passes through a vertical pipe, where it rises for several feet, meeting a heavy spray of cold water, and thence passes directly to the fuel gas holder, which serves as a relief valve during the periods of reversal of the gas from one side of the coke oven to the other. All the seals on the cleaning apparatus discharge into a concrete decanter, which has several different compartments. In this decanter the tar and pitch separate from the water and suitable means are provided for the disposal of these materials. (Fig. 19.)

A set of centrifugal pumps is provided for handling the various circulations of hot, cold and warm water utilized. A suction pipe at the extreme end of the decanter takes the hot water to a pump, which sprays it in a cooling pond, where it is sufficiently cooled for reuse. The cold water from the cooling pond is drawn back and pumped over the washer cooler, tar separator and other places where a spray of cold water may be necessary. Hot water is secured by a suction line placed directly beneath the washer cooler, and hot water is used on the dust catcher, collection main and barbotage or other places where it may be temporarily desired.

The final results of this plant have not yet been definitely determined, but it has already demonstrated its ability to make absolutely clean gas within certain definite ranges, although the exact capacity of the plant as a whole has not been entirely demonstrated.

Minerals Relief Commission

The following procedure has been adopted in connection with claims arising under the Act of March 2, 1919, known as the Minerals Relief Act:

After the findings of the Minerals Relief Commission have been made, twenty days will be allowed claimant to file typewritten or printed brief based upon the record already made, making such comment on the Commission's findings as may be desired. At the end of 20 days the case will be finally submitted to the Secretary of the Interior. No new facts will be considered, those which have been submitted to the Commission only being given consideration. No oral argument will be heard.

Government Ownership of Water Power in Relation to Electrochemical Industry*

By F. A. J. FitzGerald

THE examination of government ownership of hydro-electric developments in relation to electrochemical industry should cover a study of the effect of government ownership on the hydro-electric system considered as a productive industry in itself; the effect of this ownership on electrochemical industries which depend for their supply of electricity on the hydro-electric system; the effect of this ownership on the small user of electricity, such as the householder, and the nation at large.

Now, as regards the last consideration, it is not necessary to do more here than emphasize the fact that electrochemistry has become of such vast importance to the well-being of all the people that anything which affects its development adversely is bound to react on the nation as a whole. This was well brought out in a resolution of the board of directors recommended to and adopted by the American Electrochemical Society at its thirty-first general meeting in Detroit, May 3, 1917[1]. This report also emphasized the self-evident point that for the successful development of electrochemical industry an abundant supply of cheap electric energy is necessary. Therefore, in this report we may confine ourselves simply to a consideration of the effect of government ownership of hydro-electric systems considered as industrial undertakings.

Arguments Based on Theory

Arguments in favor of government ownership of hydro-electric systems are based usually on theoretical grounds, because, with an exception to be noted later, we have no good example of this specific kind of government ownership from which to draw conclusions. It is pointed out that the chief item in the cost of water-power developments is the interest on the investment and that governments can accordingly construct and operate such systems much more cheaply than can private companies. The government can borrow money at a much lower rate than private individuals can, and, since it is not in the business for the sake of profit, it will establish suitable sinking funds to pay off all the investment, and eventually every one—the householder, the factory needing mechanical power, the railways, electrochemical industries—will get electric energy at an actual cost which is far below anything which we can now conceive. Furthermore, it is argued that, on account of governments being in a position to develop water powers much more cheaply than private individuals can, many of these which must inevitably go to waste if left to private initiative would be utilized, to the great benefit of the people.

In reply to these theoretical arguments certain examples of government ownership may be cited and must be given considerable weight, because they are examples of government ownership in actual practice and not merely deductive arguments based on theoretical considerations.

*An address delivered at the meeting of the American Electrochemical Society, New York City, April 3, 1919.

[1] *Transactions*, Am. Electrochemical Soc. (1917), XXXI, 16 *et seq.*

A classical example of government ownership is found in the case of the Chemin de fer de l'Ouest in France, which is well known to compare most unfavorably with the privately owned railways.

Perhaps, however, one of the best examples of the failure of government ownership is found in the British telegraph system. This was originally a private enterprise, but was taken over by the government in 1870. For the first two years, that is, during 1870 and 1871, the government made a small profit after paying interest on the debentures issued for the purchase of the system, but since that time the system has been run at a loss. In 1914 the Rt. Hon. Sir Charles Hobhouse, the Postmaster General, in a speech in the House of Commons, declared that in the last 40 years the British Government's expenditures on the telegraph system, not including interest on annual losses, or any provision for amortization, were in excess of receipts by $110,000,000, while if the interest on losses and amortization were charged the loss would be $200,000,000. The average annual operating loss for the years 1908 to 1915, inclusive, amounted to over $2,000,000, while for the same period the average loss, including interest and new money expended, amounted to more than $5,500,000. In 1916 a committee appointed by the government to investigate the possibility of saving money in government expenditures stated in regard to the telegraph system:

"The history of the telegraphs is most unsatisfactory. They were taken over in 1870 at a cost (including capital expenditures on extensions) of £10,129,687 in the anticipation that they would yield a profit to the State. After the second year of Post Office management the profit failed to cover interest on the capital outlay. Year by year the financial position has grown worse and worse. In recent years the loss upon working has not been less than £1,000,000 a year, and this loss includes nothing for interest due to the State upon the aggregate losses of previous years."

Manitoba's Experience With Telephones

Another example of government ownership that is, perhaps, more interesting than the British telegraph system because it is found on this continent and because it is an undertaking initiated much more recently is the telephone system of the Province of Manitoba, Canada. It has been the subject of a most valuable and interesting study by Prof. James Mavor of the University of Toronto, published in book form by Moffat, Yard & Co. of New York and the MacLean Publishing Co. of Toronto under the title "Government Telephones; The Experience of Manitoba, Canada."

The Manitoba government took over the telephones in 1907 and Professor Mavor's study covers the history of this experiment from that time till 1915. It would take too much space to review the book here, but we may quote one of the final conclusions amply borne out by Professor Mavor's masterly study:

"The entire history of the government telephone enterprise in Manitoba affords evidence of the most positive character against government ownership. Practically all of the defects which have emerged elsewhere in the management of industries by State officials have made their appearance in the case of the Manitoba telephones. The management has been uneconomical, the enterprise has been handicapped by political intrigue, the finances, mingled as they have been with the general finances of the Province, have been unsoundly administered from the beginning, and the obligations of the public have been enormously increased without adequate compensatory advantages.

"It is possible that only by repeated and costly failures such as the Manitoba government telephones will the public realize that the proper function of government is not the conduct of industries, but the impartial inspection of them under intelligent laws adapted to the character and conditions of the community and the country."[2]

These are typical examples where we might expect to find confirmation of the arguments advanced by advocates of government ownership, but this is lacking.

Hydro-Electric Commission of Ontario

As regards the government ownership of water powers we have fortunately one large-scale experiment in the case of the Hydro-Electric Commission of Ontario. This system is composed of several different parts throughout the Province of Ontario, Canada, and up to Oct. 31, 1917, involved a total capital expenditure of $36,976,900.99.[3]

The first important agitation looking toward government ownership of water powers in Ontario apparently began in 1900, when the Board of Trade of the City of Toronto applied to the Legislature for power to undertake the development and transmission of electricity from Niagara Falls.[4] This application was not favorably received, but the agitation in favor of public ownership continued and finally in January, 1906, the government appointed the Hydro-Electric Commission of Ontario. This Commission was given very great power, as may be seen from a study of the legislation which has been enacted and which may be found in a bluebook entitled "The Power Commission Act and the Hydro-Electric Railway Act," etc., published by A. T. Wilgress, Toronto, 1917. This bluebook will in future be referred to as "The Power Commission Act."

Originally the Hydro-Electric Commission was supposed to engage merely in the transmission and distribution of electric current; but it soon determined to undertake the generation of electricity on its own account, to construct its own hydro-electric plants, to compete with private companies, and there can be little doubt that it intends, if possible, to monopolize the hydro-electric systems of Ontario, judging from the statement of its chairman, Sir Adam Beck.[5]

It would, of course, be impossible in this report to make anything approaching an adequate review of the results of the Hydro-Electric Commission's activities, but reference should be made to an extremely interesting study of these in a pamphlet entitled "Public Ownership and the Hydro-Electric Commission of Ontario," published by the MacLean Publishing Co., Ltd., Toronto, 1917. This contains a reprint of a series of articles by Professor James Mavor of the University of Toronto as well as certain other articles which appeared in the *Financial Post* of Canada. Future references to this will be abbreviated to "Public Ownership."

Twelve Objections to Government Ownership

In his examination of the Hydro-Electric Commission Professor Mavor considers twelve objections to gov-

[2] "Government Telephones," by James Mavor, pp. 163-164.
[3] Hearings before the Committee on Water Powers of the House of Representatives, Sixty-fifth Congress, Part 3, p. 725 *et seq.*
[4] Ibid., p. 702.
[5] Hearings before the Committee on Water Power.

ernment ownership and illustrates these from the history of the Ontario scheme. These objections may be briefly set forth as follows:

1. Increase in political power is one of the main motives in public ownership.

2. The conduct of industrial enterprises by government officials is not subject to inspection by impartial authorities.

3. The management of publicly owned enterprises is ineconomical.

4. In entering into industrial undertakings the government is apt to minimize the risks involved and to underestimate the amount of capital required.

5. Government officials are reluctant to provide for the continuity of the enterprise by setting aside adequate depreciation and reserve funds.

6. In governmental activities of this character there is a tendency to promote the illusion that profits inhere in industrial enterprises and to disregard the fact that, save in rare cases of adventitious profits, these are due to economy and skill in management.

7. The tendency to overman governmental enterprises of this character and the engagement of employees on political rather than technical grounds.

8. The tendency to fix the price of the governmental product at an arbitrary amount so as to induce the public to believe that the service is being rendered cheaply rather than at a rate determined by the technical conditions of the enterprise.

9. The tendency toward frequent crises in the management of the enterprise resulting from the fundamental unsoundness of the methods usually adopted.

10. The absence in governmental industrial enterprise of an experienced board of directors, its place being taken by a committee of politicians or the nominees of politicians.

11. A government preoccupied with industrial enterprises neglects its proper functions.

12. Government ownership tends to promote the illusion that politics and business are interchangeable terms.[6]

Effect of Government Ownership on Electrochemical Industry

It will be seen that this treatment of the subject of government ownership of power plants is a consideration thereof on the broad ground of public policy, but it may be well to look for a moment in more detail on the immediate effect on electrochemical industry.

The one great argument advanced by the advocates of government ownership is that of the low price of power. There can be no question that the prices charged for domestic use by the Hydro-Electric Commission are, at least in many cases, apparently much lower than could formerly be obtained. This apparently lower rate can be reached for various reasons. For example, the Hydro-Electric Commission does not pay taxes, as a private corporation must. Then by a peculiar application of the principle of "no discrimination" it is possible to charge an extremely small rate for domestic purposes. According to Sir Adam Beck: "The small user buys electricity at the same price as the large user. There is a standard rate in every community which applies whether you use 10 hp. or 10,000 hp. In the case of domestic users the small consumer buys it for less than the large consumer."[7]

When the actual rates charged domestic consumers are examined it is found that "no discrimination" means frequently that the consideration of the cost of the service is omitted. Thus on the Niagara Falls system it is found that the domestic rates for Niagara Falls, Toronto, Kitchener, Hamilton and London are the same, though the current is generated in Niagara Falls. Now, it is obvious that the cost of the current at a place like London, more than 100 miles from Niagara Falls, must be more than at Niagara Falls, where the current is generated, yet the price charged for it is the same. Then we have in Kitchener, about 80 miles distant, Hamilton 40 miles, Toronto 80 miles, the same price.[8]

In view of such an interpretation of "no discrimination" it is not surprising that a movement is now on foot among the consumers to agitate for a "uniform rate," which means that all customers of the Hydro-Electric Commission shall pay the same rate irrespective of their distance from the place where the power is generated.

It is obvious that the cost of power to consumers in the government-owned hydro-electric system is largely governed by their voting power and under such conditions electrochemical industries are bound to suffer, since they will certainly have to bear more than their fair share of the actual cost. It therefore follows that government ownership, so far as electrochemical industries are concerned, is not desirable.

Private Companies Compete Successfully With Government

Another point that should be noticed is that, in spite of the extremely favorable conditions, such as freedom from taxation, that the government-owned system enjoys, private companies are still able to compete successfully with the government enterprise.

No one will deny that there have been many reasons for complaining of the behavior of private companies, but the evils thus resulting can be remedied through government regulation based on the principle of seeing that justice is done to all; but when the government itself engages in business enterprises of this sort there is no hope of getting justice, and herein lies the greatest danger of the government ownership of water powers. This is admirably illustrated in the case of the Ontario Hydro-Electric Commission.

The Government of Ontario through the Commissioners of the Niagara Falls Victoria Park made a contract with the Electrical Development Co. of Ontario to rent water power to it and under Clause 16 of the agreement of Jan. 29, 1903, bound itself as follows:

"The Commissioners will not themselves engage in making use of the water to generate electric, pneumatic or other power excepting for the purposes of the Park."[9]

Remarkable Legislation

This agreement, of course, stood in the way of the Hydro-Electric Commission when it undertook to generate power from the Niagara River in 1916. Accordingly the following remarkable legislation is recorded in the Ontario Niagara Development Act:

"The exercise of the powers which may be conferred by or under the authority of this act or of any of them shall not be deemed to be making use of the waters of the Niagara River to generate electric or pneumatic

[6] "Public Ownership," pp. 15-48.
[7] "Hearings before the Committee on Water Power," p. 714.
[8] "Tenth annual report of the Hydro-Electric Power Commission, Vol. II, p. 164 *et seq.*
[9] "Public Ownership," p. 7.

power within the meaning of any stipulation or condition contained in any agreement entered into by the Commissioners for the Queen Victoria Niagara Falls Park." (6 Geo. V., ch. 29, cl. 7.)[10]

Naturally enough, the Electrical Development Co. was disposed to fight the government's repudiation of i' agreement and therefore attempted to have the legality of its original contract passed on by the courts. This, however, proved to be impossible because the Hydro-Electric Commission had procured legislation of this character:

"Without the consent of the Attorney-General, no action shall be brought against the Commission or against any member thereof for anything done or omitted in the exercise of his office." (6 Edw. VII, c. 15, s. 21.)[11]

Since of the three men constituting the Hydro-Electric Commission one of them was the Attorney-General, it is not surprising that the fiat which would permit the testing of the legality of the Electrical Development Co.'s contract was refused.

The Hydro-Electric Commission also has extraordinary powers in regard to the making of regulations as to the design, construction, protection, operation, maintenance and inspection of all electrical apparatus whatsoever used in the Province of Ontario, may order compliance with these and may order power supply cut off pending such compliance.[12]

A very serious situation was created by the Hydro-Electric Commission's activities during the war, and electrochemical industries were the chief sufferers. In spite of the serious shortage of power the Commission made every endeavor to extend the use of electric power in directions which would give it political power, with the result that electrochemical industries of great importance, not only to the prosecution of the war but to normal activities, were seriously hampered by having their power supply cut off.

Recapitulation

Whatever effect, whether good or evil, government ownership of water powers has on electrochemical industry will be transmitted to the nation at large.

Arguments advanced by advocates of government ownership are generally *a priori* and not based on actual experience.

Examples of governmental activities in various fields which can be undertaken by private enterprise offer evidence strongly against public ownership in such cases.

An examination of the only adequate example of government ownership of a hydro-electric system shows that all the evils have developed that are associated with governmental activities in fields other than those for which governments are instituted among men and that the largest individual users of electric energy, the electrochemical industries, will be the most direct sufferers therefrom.

Additional Note

Since the above was written some more interesting and important information in regard to the Ontario Hydro-Electric Commission has become available in the shape of the report of Messrs. Clarkson & Sons, chartered accountants, on the accounts of the Commission. The government promised to have this investigation made in 1916[13], but the report was not apparently available to the public till March, 1918, and had evidently been kept from publication for a considerable time, as it only covers the period ended Oct. 31, 1917.

Apparently the report, in spite of its inadequate nature, is in accordance with what might be expected in a governmental enterprise of this kind. For example, the original hydro act provides in regard to payment on sinking fund account that "a municipal corporation . . . may be relieved by the Commission from payment of any sum on account of the sinking fund account for the first five years . . . the amounts . . . on sinking fund account shall be payable during the next ensuing thirty years."[14]

This has been interpreted as meaning that no municipality shall be charged any sinking fund for five years.[15] This ingenious distortion of the meaning of the act permits municipalities to conceal an actual loss on their enterprise.

It also appears that the report covers only the Provincial accounts, leaving out the systems of the municipalities which are controlled by the Commission.[16]

One remarkable charge shown by the report is a sum of $1,117,433.86 against the ratepayers of the Province, a large number of whom are in no way benefited by the Commission's enterprise. This money is for items such as "Investigations and reports on proposed municipal railways," "Demonstrations at exhibitions as to use of electricity on farms," "Engineering assistance and estimates to municipalities not under contract," etc.[17]

This charge should, of course, be against the municipalities included in the hydro combination or against such of these as were directly concerned; but had this been done the government's enterprise instead of showing the net surplus of $174,919.31, which it is made to do, would show a net deficit of $942,514.55.

Obviously this report shows that had the Commission kept "regular accounts" as required by the Act[18] "the results of an audit would show, and this report should show, that the operations have been carried on at considerably less than cost."[19]

Thus as time goes on the evidence which accumulates confirms what has already been observed in a large-scale experiment on government ownership of hydro-electric systems. It is only too obvious that those most directly affected will be the largest users of electric power, the electrochemical industries, and, looking at the subject from the broader aspect of the general good, that any partial or transient benefit derived from this encroachment of government upon industrial fields will be greatly overbalanced by permanent evil.

Decay of Woodpulp

At the spring meeting of the Technical Association of the Pulp and Paper Industry, attention was called to the annual loss of wood and pulp through decay, which has assumed such proportions as to present a serious economic problem. A resolution was adopted requesting Congress to appropriate $20,000 for the purpose of conducting investigations on the nature and habits of the fungi and bacteria causing the decay of pulp wood and woodpulp, so that methods could be devised for controlling and, if possible, preventing decay.

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[10] "The Power Commission Act," p. 176.
[11] Ibid., p. 22.
[12] Ibid., pp. 41, 42.
[13] The *Financial Post*, Toronto, March 3, 1917.
[14] "The Power Commission Act," p. 30.
[15] The *Financial Post*, Toronto, March 15, 1919.
[16] Ibid.
[17] Ibid.
[18] "The Power Commission Act," p. 6.
[19] The *Financial Post*, Toronto, March 15, 1919.

A New Governor for Close Pressure Regulation of Gas Exhausters and Boosters

THE pressure regulation of rotary exhausters and boosters has occupied the attention of engineers off and on for more than 50 years. The "off and on" feature of the proceeding is due not only to the circumstance that requirements for closeness of regulation have become more stringent, but also to the change from throttling regulation to cut-off regulation. In order that we may appreciate the great difference between the two types of regulation, a brief review of the underlying principles will be made.

If a rotary exhauster works between given limits of intake and discharge pressure, and if the limits are to be kept constant, the work done by the engine per revolution is also constant.

Now let, of two engines, one be regulated by a throttle governor, and one by a cut-off governor. (See Fig. 1, which represents the indicator cards of both

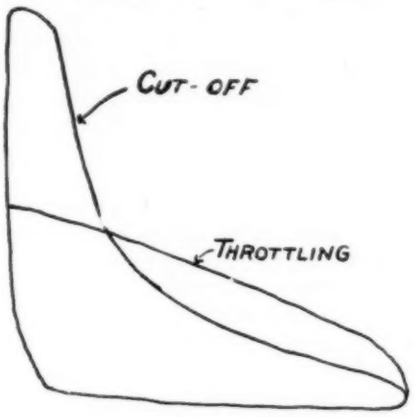


FIG. 1. INDICATOR CARDS, THROTTLE AND CUT-OFF GOVERNOR

engines.) Then in the throttling regulation, any increase in speed of the engine will, for a given position of the governor, result in greater throttling loss and in less work per revolution. If the engine tries to slow down it is speeded up, and if it tries to speed up, it is immediately slowed down to its original speed. Conditions are, therefore, inherently stable.

It is quite different with cut-off regulation. If the engine speeds up, the work per revolution remains practically constant, and no large force is brought into play to bring the speed back to normal, unless that force comes from the engine governor.

Small self-regulating forces are brought into action, whenever a change of speed occurs, on account of friction of live steam and of exhaust steam through valves, ports and pipes, and on account of friction of the gas through pipes, tar extractors and the like. However, these forces are very, very small, and cannot be depended upon, except when changes in gas volume, steam pressure or back pressure are exceedingly slow and gradual.

While this fact has been known for quite some time in the governing of air compressors, it had, apparently, not been realized to the same extent in the governing of rotary blowers. The probable reason for this lack of application of correct principles of governing is the very general use of throttling regulation in connection with rotary exhausters; and that type of regulation is justified wherever the demand of the ammonia stills for exhaust steam exceeds the supply of exhaust steam coming from a high class steam engine with cut-off regulation. On the other hand, the requirements for closeness of regulation are very much closer in the governing of gas exhausters than they are in the case of air compressors. This statement is substantiated by the following facts: In air compressor practice, a pressure fluctuation of 5 lb. per sq.in. is not considered serious. If the air pressure be 85 lb. per sq.in., then 5 lb. is 5 per cent of the absolute pressure (85 plus 15 lb.). In gas exhausters, particularly in connection with by-product extraction, the pressure at the exhauster is to be kept constant within 5 mm. of water. Since atmospheric pressure roughly equals 10,000 mm. of water, the required closeness of regulation equals $5 \times 100 \div 10{,}000 = 0.05$ per cent. This means that in modern gas exhausters the regulation must be 100 times as close as it is in compressor practice.

Although it is very interesting to follow the development of exhauster governors in history, such study would lead altogether too far in the present article. For that reason, we will now describe the new pressure governor, calling attention, as we go, to the various features. The governor in question is made by the P. H. & F. M. Roots Co., of Connersville, Ind.

To be successful for close regulation, a pressure governor must instantly react upon the slightest change of pressure. Compliance with this requirement is much more essential in relay governing than in direct control governing, because the float is practically free from all vibratory forces so that the harmful effects of detention of the governor by friction appear with full measure. Even a slight amount of friction causes the pressure to vary rhythmically up and down over a considerable range. For that reason, sensitive pressure governors have always been made of the float type, and the Roots governor, shown in Fig. 2, is no exception to that rule. To avoid any and all solid friction, the governor is, for work on gas exhauster suction lines, buoyed up by means of an air chamber, and adjustment of suction is obtained by placing weights on the weight holder (4) below the tank. This arrangement necessitates an additional water seal in the center of the float, but the entire freedom from friction is worth the additional parts.

A very great difficulty with sensitive float governors is hunting, or surging. If the pressure departs from the normal value, the governor sets out to change the position of the valve gear. The adjustment continues not only to the point where the volume taken away by the exhauster equals the incoming volume, but beyond that point, because the pressure cannot be returned to the original value, unless the accumulated excess or deficiency of volume has been made up. When this end has been accomplished the governor is away out of the right position and the speed is away off. It takes a new, greater change of pressure in the opposite direction to bring the governor back to initial position, and the surges and vibrations become greater and greater. In the governor under consideration the difficulty is overcome by a temporary stability, which keeps the governor from following the influence of pressure too far.

To that end it is equipped with a stabilizing chamber which is partly filled with water. If the float tends to rise under the influence of less vacuum inside of it, the water in the stabilizing chamber is lifted, so that

the float becomes heavier and resists being carried too far. It tends to come back to the original position. But it may be that the float would not settle in the original position, because steam pressure, back pressure or discharge pressure may have changed.

To enable the float to find its correct final position, the stabilizing chamber is made leaky on purpose, the extent of the leak being determined by an adjustable valve. The adjusting screw is visible at 3. With

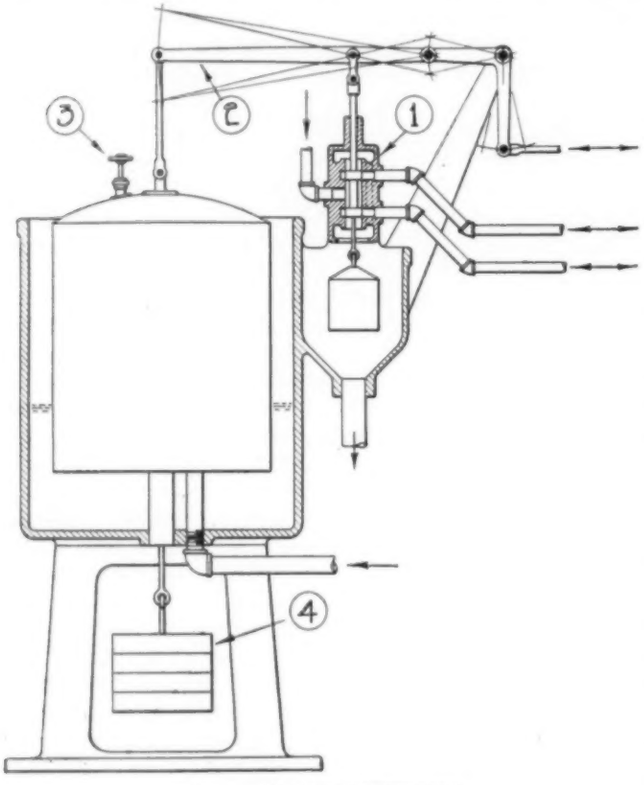


FIG. 2. ROOTS GOVERNOR

that valve wide open, the governor surges; with the valve dead shut, the governor does not maintain a constant pressure, but adjusts for different pressures in the gas suction line with different combinations of steam pressure, back pressure and discharge pressure. The best opening of the valve is easily found in practice.

This temporary stability results in very fine regulation. If a disturbance of equilibrium occurs, the suction pressure departs slightly from the normal value, but a few oscillations with gradually decreasing amplitude soon bring the pressure back to the original value. In actual operation, this feature of the governor is easily tested by depressing the float away from its correct position and then letting go of it quite suddenly, or else by suddenly opening the by-pass from the discharge to suction on the exhauster. In either case the governor takes hold of the situation almost instantly.

The motion of the float is communicated to a vertical pilot valve 1 by means of light rods with very small pin joints which approach frictionless knife edges in their action. The pilot valve is made heavy on purpose, and is suspended from a floating lever, one end of which rests on a float, while the other end floats on the compensating return, the purpose of which is described below. In that manner, lost motion is eliminated and the slighest motion of the float is immediately transmitted to the pilot valve. The latter is made with an open-view discharge. Leaky pilot valves are a prolific source of trouble, because they require considerable travel of the governor before the pressure fluid acts upon the power cylinder. With closed discharge pipes, leaks are not discovered until the regulation becomes defective, and at that time almost every other part of the governing system is suspected, except the pilot valve. With an open discharge, a leak is plainly visible and is corrected before the regulation becomes defective. Too much emphasis can hardly be placed on this feature. In many relay governors, regulation gradually loses its precision due to increasing leakage of the pilot valve, and the engine or turbine operators are unable to locate the trouble, but if defective regulation is caused by a leaky pilot valve, the visible discharge shows it.

The compensating return of the pilot valve is a feature which is well known in governing practice. (See Trinks, "Governors, and the Governing of Prime Movers," Van Nostrand, 1919.)

Without such returning mechanism, the slightest displacement of the pilot valve causes the valve gear of the engine to be moved away continuously from its starting position, until the resulting speed change and pressure change moves the governor and displaces the pilot valve in the opposite direction. The governor surges or hunts, and never comes to rest, unless accidentally the valve gear is in correct position while the pilot valve is closed and when the governor is at rest.

To avoid this trouble, the compensating return was provided. Lever 2 is so connected to the valve gear that motion of the valve gear, induced by opening of the pilot valve, closes the latter. The valve gear cannot run away from the pilot valve, and all causes for hunting and surging are removed.

The closeness of regulation obtained with the Roots governor depends to a certain extent upon the power requirements of the engine valve gear. With releasing gear for Corliss or poppet valves, 3 mm. total fluctuation of suction pressure can be obtained, except during periods of excessively quick change in gas volume, steam pressure, back pressure or discharge pressure, when the pressure fluctuation may reach 10 to 15 mm. of water. With non-releasing valve gear, requiring power cylinders of great volume, the total pressure fluctuation will rise to 5 or 6 mm. of water, with peaks of 15 to 20 mm. for the first wave of excessively sudden disturbances.

The difference in closeness of regulation is caused by the greater requirements of pressure fluid in the power cylinder for adjusting non-releasing gears. If the pilot valve be made large, to admit oil or water in quick flow to the power cylinder, the frictional resistance of the pilot valve detains the governor. If the pilot valve be made small enough not to detain the governor, the flow of oil or water is insufficient to get quick action out of the power cylinder. To get the same closeness of regulation, both for non-releasing gear and for releasing gear, would require a much larger float for the former.

The Roots governor is made independently of exhauster contracts, and is furnished separately to improve the regulation of existing installations. Patents are pending, covering the principal features of the governing device. The best sizes of float, of buoyancy and stabilizing chambers, of leakage valve, of pilot valve, of pilot-valve weight and of sizes of ports are the final outcome of several years of close study and expensive experimental research.

Synopsis of Recent Chemical and Metallurgical Literature

Automatic Heating Furnaces.—Figs. 1 and 2 show sections of an automatic heat-treating furnace described by A. F. MITCHELL, metallurgical engineer, ordnance department, U. S. Steel Corporation, in the January, 1919, issue of the *Blast Furnace and Steel Plant*. Shells are fed into and through this furnace automatically, being rotated during their forward travel; while in the furnace they are supported upon cast iron plungers operating through the bottom of the furnace and are not only kept separated, but are held several inches above the floor, thus insuring perfectly uniform heat in the minimum time. The furnace itself is quite substantially built, as is evident from Fig. 3. It is heated by means of side gas burners, whose flame impinges directly upon a mass of refractory material shown in the cross-section. Careful regulation of the gas composition is important so that the non-oxidizing atmosphere within the furnace may be under complete control and so that there will be no fuel loss due to imperfect combustion. Indirect heating by reverberation has eliminated heavy metal losses by surface oxidation, and in conjunction with an enlarged heating chamber has insured a much better distribution of heat. It has also been completely demonstrated that money spent in adequate insulation of roof and side walls is soon recovered by the largely increased fuel efficiency.

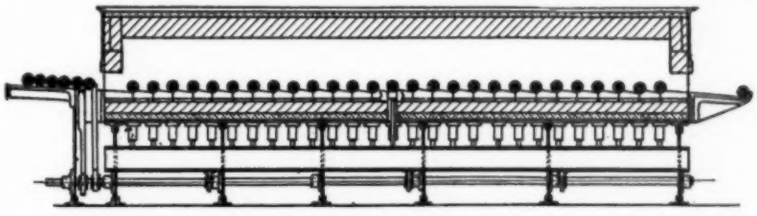


FIG. 1. LONGITUDINAL SECTION OF SHELL HEATING FURNACE

Solders for Aluminum.—Bureau of Standards circular No. 78 notes that aluminum is easily welded by oxy-gas processes, but ordinary soldering methods are somewhat difficult to apply. It is essential to prepare a clean, bright surface, which is then "tinned" by a high-melting solder with no flux. The Bureau recommends those compositions containing high percentages of zinc and aluminum selected from the suggested ranges given below:

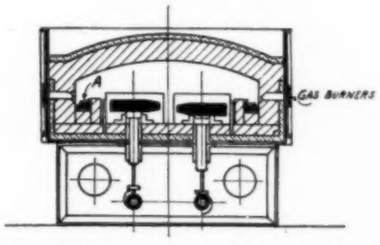


FIG. 2. CROSS-SECTION. A—REFRACTORY MATERIAL

Tin-zinc solders:	
Tin	Remainder
Zinc, per cent	15–50
Tin-zinc-aluminum solders:	
Tin	Remainder
Zinc, per cent	8–15
Aluminum, per cent	5–12

A perfect joint is very difficult and can be had only at relatively high temperature. When the two pieces are properly "tinned," any ordinary soft solder will join them together. However, any solder compound examined is electro-negative to aluminum, and consequently the joint must be carefully and continuously protected from corrosion by paint or varnish, otherwise it will rapidly disintegrate and the pieces fall apart.

Working Results of a Rennerfelt Electric Steel Furnace.—In the course of the discussion of a paper on the "Prospects of the Electric Steel Furnace in Sweden," by Mr. OTTO FRICK, Mr. I. RENNERFELT and Chief Engineer H. VON ECKERMANN put in the figures as actual results, with a 1¼ ton Rennerfelt furnace (arc-type), at Ljusne in Sweden, during the five days, from Nov. 21 to 25, 1916. According to them, 12 charges were dealt with in the furnace in question, the average net time per charge being 6 hr. 39 min. The average input was 1.27 metric tons, of which 19.5 per cent consisted of common Swedish gray pig iron, 6.5 per cent of billet croppings, 64.5 per cent of bar croppings, and 9.5 per cent of scrap. The additions were in eleven of the charges, ferromanganese and ferrosilicon, plus, in five charges, small doses of aluminum, some flux being added (Kiiruna ore = 1.8 per cent average of the charge) in every case, plus a small quantity of lime in one case. The average output (including scrap left) was 1236 metric tons per charge; hence the loss was 2.44 per cent. The scrap left over represented 10.12 per cent of the weight of the ingots and direct castings produced. The consumption of electrodes was 5.1 kg. (11.22 lb.) per metric ton (2.205 lb.), and the energy consumed 1010 kw.-hr. per metric ton of steel (with 0.21 per cent carbon) produced. The work of the furnace was intermittent, hence the larger consumption of energy. With continuous working and producing steel with a carbon content of 1.20 per cent the chief engineer thought the average current consumption could be reduced to 800 kw.-hr. per ton of steel produced.—*Indian Engineering*, March 16, 1918, p. 149.

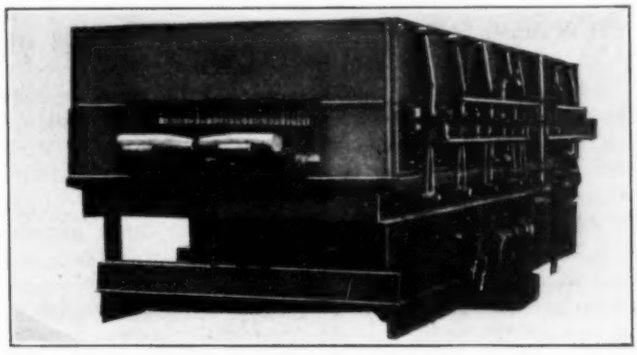


FIG. 3. AUTOMATIC HEATING FURNACE

Volatilization of Gold.—Literature contains many efforts to determine the volatility of gold, and from this contradictory evidence Sir THOMAS K. ROSE, in a paper presented before the Institution of Mining and Metallurgy, Mar. 20, 1919, deduces the following factors affecting volatilization: Time, temperature, amount of exposed surface, composition of bullion, composition of atmosphere, and movement of atmosphere. Preliminary experiments to harmonize the pub-

lished information gave the most inconsistent results. The apparatus consisted of a quartz tube, gas heated, discharging into a condensing system. Microscopic examination of the condensed films showed them to consist of a multitude of spheres, of the order of 0.001 mm. diameter. Larger spheres sectioned, polished and etched gave polygonal crystalline grains, and no trace of concentric structure.

Considerable experimentation was necessary before the true blame for divergent experimental results was placed upon an inconstant atmosphere. When pure gold, or its alloys with silver or copper, are kept molten in a reducing or oxidizing atmosphere, the surface of the gold remains as a bright, motionless mirror. Under these circumstances the loss of gold is very small, being due to true volatilization. If there is a strong draught passing over the surface the loss by volatilization is naturally greater than in a still atmosphere, but is even then almost negligible at the ordinary temperatures of industrial furnaces.

Under all such conditions, however, gases are being absorbed by the metal. If the atmosphere above the gold now undergoes a change, say from an oxidizing to a reducing one, the quiet metal begins to effervesce due to the expulsion of certain of the occluded gases, possibly as new chemical combinations formed with the new atmospheric components.

Showers of globules of gold of all dimensions are thus thrown up, and the smaller sizes carried away by the current of gas. After a time, usually about 30 sec., if the reducing atmosphere is maintained, the action dies away, and the gold again becomes motionless and remains so until the reducing atmosphere is converted into an oxidizing one, when the same phenomena reappear. As molten metals occlude more hydrogen with increase of temperature, the greater losses observed at higher temperatures than at lower ones are readily explained. Other observed anomalies are due to the fact that pure gold does not occlude oxygen, hydrogen or nitrogen, while its alloys do.

It is evident that losses of really volatilized gold are extraordinarily small in industrial furnaces. Under constant atmospheric conditions, the author finds variations in weight between a loss of 0.052 to a gain of 0.017 per 1000. As a matter of fact the Royal Mint records a gross loss of between 0.2 to 0.25 per 1000, which is reduced to a net loss of 0.1 to 0.15 per 1000 after crediting the recovery from flue dust, ground crucibles and furnace bricks, ashes and sweepings. In less well conducted establishments the loss is of course much larger and may aggregate a half-million dollars per year. Under most rigid atmospheric conditions this can be enormously lessened, even granting the inevitable spirting loss which occurs when metal melted under charcoal is poured through air.

Maxima Magnetic Susceptibilities.—At the meeting of the Interallied Chemical Confederation held in Paris in April, 1919, Prof. HENRY LOUIS read a paper on the treatment of low-grade iron ores by magnetic concentration. The following table is abstracted from this paper (*Chimie et Industrie*, May, 1919).

MAXIMA MAGNETIC SUSCEPTIBILITIES PER VOL. C. G. S.

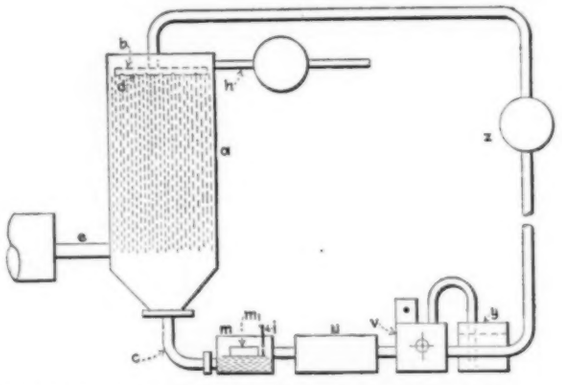
Ore	Locality	Susceptibility
Pure Soft Iron		400
Crystallized Pure Magnetite	Piemont	3.12
Magnetite	Hay Tor, Devonshire	1.44
Magnetite	Lake Champlain, U. S.	0.151
Iron Sulphide	Artificial	0.064
Red Hematite		0.00037
Brown Hematite		0.00016

Recent Chemical and Metallurgical Patents

British Patents

Extracting Ammonia From Gases.—Ammonia is extracted from hot gases, for example from furnace gases or gas producers, by a solution of a salt such as calcium chloride, or zinc chloride, possessing the property of forming a double compound with ammonia, which is delivered as a shower or spray by one or more distributing devices provided with spraying nozzles into a vessel through which the gases are caused to rise.

The apparatus comprises a vessel *a*, having a gas inlet *e* and a gas outlet *h*, and provided at the top with a liquid distributing box *b* fitted with spraying nozzles *d*. The vessel *a* is without internal projections, and is formed with a sloping bottom, so that solid matter, for example calcium carbonate, formed when the gas treated contains carbon dioxide, is washed out of the vessel. The heated liquid containing the absorbed ammonia leaves the vessel by a pipe *c* and enters a box *m*, where the dust and solid matter taken up from the gases, and which float on the solution, are separated by a scraper or filter, for example by a vertical plate *i*, a lateral opening M_1 being provided in the side of the box for the removal of the separated matter. The liquid then passes through a settling tank *u* to a tank *v* where it



APPARATUS FOR EXTRACTING AMMONIA FROM GASES

is treated with milk of lime to liberate the ammonia, and the residual solution is returned by a pump *z* to the vessel *a*. The ammonia may be absorbed in water in a vessel *y*, or a plant for producing an acid or an acid anhydride may be provided, the ammonia and acid or acid anhydride being led into a vessel to form a salt, for example ammonium nitrate may be formed from the ammonia, water vapor and nitric anhydride made by the electric arc process.

When the hot gases contain tar in addition to carbon dioxide, a portion of the tar will be washed out of the gas and will mingle with the calcium carbonate, the mixture is removed in the separating box *m* and is burned for the recovery of the lime. The remainder of the tar passes off with the treated gas and may be separated by known means.

The hot solution before treatment to liberate the ammonia may be utilized for producing steam, or for heating water or other fluids.

In a modification, the hot gases are washed or scrubbed by a water spray in a separate vessel before

entering the vessel *a*. The washing may be carried out to such a degree that the whole of the tar is removed from the gas. (British Patent No. 121,754—1918. E. L. PEASE, Darlington, Durnham. Feb. 26, 1918.)

Welding Different Metals to Steel or Iron.—Different metals are welded to steel or iron to form a composite ingot with a thin continuous sheet or strip of copper or other metal interposed between the welding surfaces, the sheet metal chosen being capable of alloying with a constituent of the metals to be welded. The metal to be welded, if of considerable thickness, may be in the form of thick sections alternating with thin sections. When a steel ingot is to be welded to another metal, the welding surfaces of the steel are first covered with tin or other easily fusible metal. (British Patent No. 122,365—1918. A. G. C. PITTEVIL, High Holborn, London. March 19, 1919.)

Refractory Bricks.—Separate portions of siliceous material, consisting chiefly of silica, one in relatively coarse powder and the other in a very finely divided condition, are mixed wet with animal or vegetable fiber, or both, to form a composition for molding. Both materials may be flint, chert stone, silica rock, quartz, sand, or stone rich in silica, calcined and the coarser is ground to 16 to 100 mesh. The fine material may or may not be calcined and will pass through a 250-mesh sieve. The fiber may be straw, chaff, peat, wool, hair or the like. The mixture of the two siliceous materials and fiber is mixed with water until the fiber is finely subdivided, molded, and the articles dried and fired at a temperature above 1500 deg. C. (British Patent No. 122,388—1918. C. H. SANKEY WILDCROFT, Chislehurst, Kent, and J. E. FOSTER, 48 Gilman St., Hanley, Stoke-on-Trent. March 26, 1919.)

Preparation of Dimethyl Sulphate.—Dimethyl sulphate is prepared by the reaction of sulphur trioxide on dimethyl ether in the presence of a solvent or diluent, preferably dimethyl sulphate itself. The sulphur trioxide used is preferably diluted with an indifferent gas; thus a current of air may be passed through hot fuming sulphuric acid and the resulting mixture of air and sulphur trioxide used, or the mixture of air, sulphur dioxide and sulphur trioxide resulting from the contact process of making sulphur trioxide may be used. The product of the reaction is treated either with ice or preferably with a reducing agent such as iron filings to destroy any sulphur trioxide present, and is purified by vacuum distillation. (British Patent No. 122,498—1918. W. N. HAWORTH and J. C. IRVINE, University, St. Andrews, Fifeshire. March 26, 1919.)

Sulphuryl Chloride.—A mixture of sulphur dioxide and chlorine in equimolecular proportions is passed over charcoal which acts as a catalyst to produce the combination with evolution of heat. The temperature should preferably be kept down to about 30 deg. C. (British Patent No. 122,516—1918. W. J. POPE, Holmesdale, Brooklands Avenue, Cambridge, March 26, 1919.)

Electrolytic Detinning Process.—An electrolyte for the recovery of tin from scrap and waste consists of a 7 to 10 per cent solution of caustic soda or potash in which is dissolved 1 per cent of stannous chloride. It is preferably heated to 180 deg. F. by a steam pipe. The scrap may first be washed in a caustic alkali or other solution to remove paper, etc., and placed in a perforated drum. (See British Patent No. 122,025—1918, for detailed description of this drum.) The drum is removed to the electrolytic vat and rotated or oscillated. After electrolysis, the drum is washed in water and the liquid is concentrated for restoration to the electrolyte. Two vats are preferably used alternately for washing and evaporating. The drum is next removed to a solder-recovery plant, and the residual scrap is discharged into baling presses. (British Patent No. 122,618—1918. Sir H. GREVILLE LODGE, Sir Harry's Road, Edgbaston; M. L. LANCASTER, Arden House, Stechford; C. M. WALTER, Lichfield Road, Four Oaks, and J. JACKSON, 70 Oxford Road, Moseley, all in Birmingham. March 26, 1919.)

Book Reviews

METALLURGY OF LEAD. By *H. O. Hofman*, Professor of Metallurgy, Massachusetts Institute of Technology and Harvard University. First Edition, 1918; XIV + 664 pages, 705 illustrations, 153 tables. New York: McGraw-Hill Book Company, Inc.

Professor Hofman's earlier work on "The Metallurgy of Lead and the Desilverization of Base Bullion" has not been revised since 1899. Originally published in 1892, it at best now represents details of practice since largely changed in modernized and recently-built American plants. The character of the ores treated has gradually changed due to the constant exhaustion of older mines and discovery of new, while the universal adoption of blast roasting is not only one phase of the trend toward economy of man power but has profoundly affected the entire lead-plant economy, from a metallurgical viewpoint.

Consequently this new book devotes 330 pages to a chapter on Blast-Furnace Smelting and 170 more to Desilverization of Bullion, a total of 500. Short chapters on smelting in the ore hearth, and in the reverberatory, on lead smelting, and on the properties of lead, its ores, compounds and alloys, make up the remainder of the book, exclusive of a comprehensive index.

In style the book follows the author's monumental "General Metallurgy" published a few years ago. Professor Hofman has been reviewing the pyrometallurgy of lead for "The Mineral Industry" annually since 1892, and the abstracts of contemporary literature contained in great numbers give both these books an encyclopædic value. However, the style is discontinuous and extremely difficult to read, giving the impression at times that the book is a compilation of dictated and card-indexed notes rather than that of a deliberate commentator on an intricate subject. Thus, there are illustrated and briefly described a large number of equilibrium diagrams of binary systems of compounds present in slags, mattes and other furnace products, but little indication how these studies may bear upon successful lead smelting. On the other hand a most excellent discussion of the chemistry of the blast-furnace is given on pages 339 to 345, which could readily have been expanded in many points and the connection between physicochemical theory and metallurgical practice pointed out at some length. Another contrast in style is unexpected of an author who uses the terms "smeltery," "wedge kiln," and puts a period after "per cent," yet uses through the running text chemical symbols of all metals and common compounds as well as such hybrids as "S-ides."

But enough of this side of the book. It is a monument to the extraordinary industry of the author, in that it contains a brief statement of all the scattered technical literature down to the time of going to press. Apparently the notable smelters and refineries in the United States were toured at intervals, and a lively correspondence maintained with their operators on technical matters, since the book abounds with observations culled from private notes and communications. Most notable is the excellent metallurgical and thermal balance sheet of blast-furnace practice at Herculaneum, Mo. Again, two very good general layouts

of complete and modern plants are given, one of the Bunker Hill and Sullivan smelter at Kellogg, Idaho, and a second design by Mr. H. V. Croll. The latter is accompanied by a somewhat detailed estimate of the cost of construction—in fact, the author should be praised for uniformly including in his estimates the *quantities* of materials used, in honorable contradistinction to others who apparently think that $100 worth of brick are $100 worth of brick!

It would be difficult to justify criticism as to the relative amount of space devoted to various divisions of the subject. Thus Professor Hofman passes by mechanical roasters with a brief mention, to devote a great deal of space to the almost extinct hand-reverberatory. However, in his very thorough discussion of blast-roasting (well worthy of the attention it is given) he returns to the subject of mechanical roasting in an adequate manner.

The size of the book under discussion and the limits accorded a reviewer forbid any more than casual mention of the most striking features of the major chapter, and entirely preclude detailed analysis and discussion of the few controversial points left by our somewhat standardized American practice. Enough has been said, however, to indicate the grounds of the reviewer's opinion that the book will be of tremendous value to the studious workers in lead metallurgy, primarily because of its minute review of literature and present plant practice—as a compilation it is wonderful! On the other hand it will be as difficult a book to teach, having the same failing as has his earlier "General Metallurgy"; that is, in his mass of detail of various plants, appliances and citations, there are too few cases where the author leads the young student to form correct opinions by pointing out the principles underlying a design, or discussing the relative advantages for the particular problem in hand—as a critique it is a disappointment! Perhaps it is as difficult to write in a manner instructive at once to the expert and the student as it is to purchase a single suit wearable on all occasions!

E. E. THUM.

Personal

MR. LESTER E. ARMSTRONG has accepted a position as advisory engineer with the Powdered Coal Engineering & Equipment Co., Chicago, Ill. Prior to his service in the Air Branch of the Army, Mr. Armstrong was associated with Babcock & Wilcox.

The duPont scholarship for the year 1919-20 at the College of the City of New York, Department of Chemistry, has been awarded to FELIX BRAUDE.

MR. A. G. GREENAMYER, formerly of the Pittsburgh Crucible Steel Co., Pittsburgh, Pa., has accepted the position of metallurgist with the Donner Steel Co.

DR. GEORGE ELLERY HALE, director of the Mount Wilson Observatory and foreign secretary of the National Academy of Sciences, who has been for the last ten years a correspondent of the Academie des Sciences, Institut de France, has received the unusual honor of election as Associé Etranger, taking the place of Adolph von Baeyer, declared vacant by the Academy. The Foreign Associates are limited to twelve, and the high distinction has been held by only two Americans—Simon Newcomb and Alexander Agassiz. The National Research Council, upon the presentation and acceptance of Dr. Hale's resignation as its chairman and the election of James R. Angell as his successor, created and bestowed in perpetuity upon Dr. Hale the title of honorary chairman in recognition of his services to the National Research Council and to science and research by indefatigable efforts that have contributed so largely to the organization of science for the assistance of the Government during the war, and the augmentation of the resources of the United States through the newly intensive cultivation of research in the reconstruction and peace periods that follow.

DR. ARTHUR W. HIXSON has been appointed associate professor of chemical engineering at Columbia University. He entered on the duties of his new position July 1. Prof. Hixson was formerly associate professor of industrial chemistry and metallurgy at the University of Iowa, but for the last year he has been in the Ordnance Department at Washington.

MR. E. R LEDERER, formerly superintendent of the Petroleum Refining Co. of Texas, has accepted a position with the Home Oil Refining Co. of Texas, Fort Worth, Tex., as general superintednent.

Leland Stanford, Jr., University has recently created a graduate department of mining and metallurgy which will be under the direction of THEODORE J. HOOVER. The chair of metallurgy will be held by JAMES M. HYDE.

MR. A. LUSSKIN is now research chemist with the International Oxygen Co., Newark, N. J. Mr. Lusskin was formerly on the chemical engineering staff of the Air Nitrates Corporation, Muscle Shoals, Ala.

DR. J. J. MORGAN, assistant professor of chemistry at Stevens Institute of Technology, Hoboken, N. J., has been appointed assistant professor of chemical engineering at Columbia University, New York City. Professor Morgan will enter on the work of his new position the coming September.

MAJOR STERLING TEMPLE has received his discharge from the Service at Edgewood Arsenal and is now research chemist for the Roessler & Hasslacher Chemical Co., Perth Amboy, N. J.

COL. WILLIAM H. WALKER has been awarded the Distinguished Service Medal for exceptionally meritorious and conspicuous service. His extraordinary technical ability, untiring industry and great zeal enabled remarkable results to be achieved in the production division of the Chemical Warfare Service in the face of many obstacles.

DR. E. W. WASHBURN, acting chairman of the division of chemistry and chemical engineering, National Research Council, and DR. CHARLES L. PARSONS, chief chemist of the U. S. Bureau of Mines, sailed June 30 for London to attend the meeting of the International Chemical Union beginning July 15. Dr. Washburn will then go to Brussels as chairman of the American delegation of the International Chemical Union to attend meetings of the International Research Council and affiliated organizations beginning July 18.

MR. GEORGE J. YOUNG of the editorial staff of *Engineering and Mining Journal* has been transferred from New York City to San Francisco, where he will serve in the capacity of Western editor for the *Journal*.

Obituary

LORD RAYLEIGH (John Wllliams Strutt) died on June 30 in London. Born on Nov. 12, 1842, he was educated at Trinity College, Cambridge, where he was graduated as senior wrangler in 1865 and obtained the first Smith's prize of the year. From 1879 to 1884 he was Cavendish professor of experimental physics in Cambridge University, and in 1887 he accepted the post of professor of natural philosophy at the Royal Institution of Great Britain. He was awarded the Nobel Prize for physics in 1904. Many years ago his name became well known throughout Europe by his mathematical and physical papers written under the name of "J. W. Strutt." He used plain and usually homemade apparatus, the accessories being crude and rough, but essentials thoughtfully designed so as to insure in the most perfect manner the object in view. His work was the most productive in chemical physics, theory of gases, flow of liquids, photography, optics, color vision, wave theory, and in electric and magnetic problems of all kinds. It was said of him at the time of his election as Chancellor of Cambridge University in 1908 that "since the death of Lord Kelvin he is the most eminent chemist in Christendom."

MR. BOVERTON REDWOOD, one of the world's foremost authorities in the petroleum industry, died on June 6,

1919. Mr. Redwood was well known in this country as the author of many papers and books on petroleum and allied subjects and as a consultant of high standing on petroleum questions.

MR. WILLIAM G. SHARP, president of the United States Smelting, Refining & Mining Co. since its organization in 1916, died on July 1 at his home in Wenham, Mass.

MR. EUGENE WAUGH, president of the Waugh Chemical Corp., New York City, died recently at New Rochelle, following an operation. Mr. Waugh had been with the General Chemical Co. for fifteen years.

MR. WILLIAM THUM, superintendent of the electrolytic lead refinery of the United States Metals Refining Co., East Chicago, Ind., died on June 28, 1919, at his home in Hammond, Ind., after a brief illness from pneumonia. Mr. Thum was born in Germany in 1863 and received his early education there preparatory to the university. In 1879, however, he came to the United States with his father, F. A. Thum, who was a graduate mining engineer of the Clausthal School of Mines. In 1883 William Thum was made assistant superintedent of the electrolytic copper refining department of the Balbach Smelting & Refining Co., Newark, N. J., and there, in association with his father, he laid the foundation of electrolytic refining in the United States. At that time the Balbach company was using the Parkes process of lead refining, which was superseded by the electrolytic developments of Mr. Thum and his father. In 1904 Mr. Thum was made superintendent of the DeLamar Copper Refining Co., Chrome, N. J., and in 1906 he was sent to Chicago by the United States Metals Refining Co. in the capacity of superintendent of the electrolytic refinery at East Chicago, Ind. This was the first plant of its kind in the United States, although there were others at Trail, B. C., and at Newcastle-on-Tyne. It was at East Chicago that Mr. Thum developed a number of metallurgical processes, some of which he patented. These related to the recovery of bismuth, tellurium and antimony as by-products in electrolytic lead refining; other patents related to apparatus for use in the Pattersonizing process and electrolytic cell for parting Doré bullion. In addition to his attainments in metallurgy Mr. Thum showed unusual versatility in the arts. He painted in oils and water colors. He spoke French, German and English with equal fluency and read Latin with ease. His interest in outdoor life led him to acquire an extensive knowledge of birds and animals and took him to the hunting grounds of Maine. His sympathy with all good movements was shown during the war by his activity in Liberty Loan campaigns, and in the work of patriotic societies of the East Chicago-Hammond district of Indiana.

Current Market Reports

The Non-Ferrous Metal Market

Wednesday, July 9.—Prices have continued to rise during the past fortnight. Anticipation of orders from Central Powers has aided in strengthening the market.

Aluminum:—To be in equilibrium with the other metals on a pre-war basis, aluminum should decline; however, the holders are strong and can be induced to lower prices only to meet foreign competition. A price of 32c. lb. is quoted on 98-99 per cent ingot. Scrap has advanced: Cast 20-24c.; sheet, 21-24c., and clippings, 23-26c. Sheets, 18 gage and heavier, 41c., with some munition offerings at 36c. Powder, 5-ton lots, 45c.

Antimony:—Spot quotations continue at 8¾c., futures at 8¼c., and small job lots at 8⅝c. It is believed that no immediate changes will occur.

Copper:—Small sales have been made on electrolytic spot at 19⅞c., casting at 19c., but lake July and August price is at 20c. September futures are reported at 20¼c. The Government has liquidated its surplus of 114,000,000 lb.

The aggregate sales per week are large. Wire-drawers are the principal buyers, with brass foundrymen a close second. Japan has been buying heavily, the domestic output there last year having been lower than usual, 95,000 tons, of which 31,662 was exported. Only 1000 tons was imported from America due to the war embargo.

Copper sheets, hot-rolled	lb.	$28.50 —	.....
Copper sheets, cold rolled	lb.	29.50 —	.....
Copper bottoms	lb.	36.50 —	.....
Copper rods	lb.	20.75 —	$21.00
Copper wire	lb.	21.50 —	21.75
High brass wire and sheets	lb.	23.75 —	.....
High brass rods	lb.	22.25 —	.....
Low brass wire and sheets	lb.	26.00 —	.....
Low brass rods	lb.	16.75 —	.....
Brazed brass tubing	lb.	34.75 —	.....
Brazed bronze tubing	lb.	39.25 —	.....
Seamless copper tubing	lb.	33.00 —	.....
Seamless bronze tubing	lb.	39.25 —	.....
Seamless brass tubing	lb.	32.00 —	.....
Scrap, heavy machinery comp		14½ —	14¾
Scrap, heavy and wire		14¼ —	14¾
Scrap, light and bottoms		12¾ —	13
Scrap, heavy, cut and crucible		15¼ —	15½
Scrap brass, heavy		8¼ —	8½
Scrap brass, casting		10¼ —	10½
Scrap brass, light		7¼ —	7½
Scrap, No. 1 clean brass turnings		7⅞ —	8⅛
Scrap, No. 1 comp. turnings		12¼ —	12½

Lead:—The price remains at 5.4c. for New York and 5.15c. at East St. Louis. Lead sheets cut, 8.5c. lb.

Tin:—It is difficult to gage the market. Spot tin is still quoted at prices around 68c. and 70c., but with importations of tin now free after Sept. 1 and ores that have been shipped on or after June 8 due to arrive here almost any day from South America, the chances are that before long we shall have prices which will come substantially nearer the figures now quoted for shipment tin, which is at about 52c. lb.

Zinc:—Spot spelter at East St. Louis is tending to advance from 7⅛ to 7¼c. lb., New York, 7.4c.

OTHER METALS

Bismuth	lb.	$3.20 —	$3.65
Cadmium	lb.	1.40 —	.....
Cobalt	lb.	2.50 —	3.50
Magnesium	lb.	1.75 —	2.10
Mercury	75 lb.	107.00 —	.....
Nickel	lb.	.40 —	.45
Iridium	oz.	175.00 —	.....
Palladium	oz.	115.00 —	120.00
Platinum	oz.	105.00 —	107.00
Silver	oz.	106.00 —	.....

The Iron and Steel Market

Steel mill operations during the first half of July averaged between 65 and 70 per cent of capacity, against an average of about 60 per cent in June and a low point of approximately 50 per cent at the middle of May. As the increase in production has not altogether kept pace with the increase in buying that began just before the middle of May, it is clear that the recovery in the steel market is of very substantial character.

Demand has been distributed far from uniformly among the various lines of finished product, the divergence being due, of course, to varying conditions among the different classes of consumers consequent upon the war ending so recently. Some consumers were free buyers during the war, others have since become large buyers and still other prospective buyers, chiefly of the investment class, have not yet been ready to act.

Easily the most active line in finished steel products is oil country goods, the chief product of the lap weld departments of the pipe mills. This demand was rather heavy in the early months of the year and has lately been of such large volume as to fill the lap weld departments far ahead, a few mills being now sold up practically to the end of the year. Judged by all precedents, this demand is abnormally large, its expansion being due to the heavy demand for oil and oil products, the high market price and the increased number of wells necessary to produce the required output.

AUTOMOBILE TRADE ACTIVE

Next in point of activity is the automobile trade, which requires a somewhat larger tonnage of steel than at any time in the past. The automobile trade's demand is reflected most clearly in the sheet and cold drawn industries. Sheet mills are operating at more than 80 per cent of capacity, chiefly by reason of the demands of the automobile trade, as the demand for sheets for building purposes is relatively light. Makers of cold drawn shafting and screw

stock are operating at about 80 per cent of capacity, against only about 60 per cent 30 days ago, and attribute the increase in their business chiefly to demand from the automobile trade. Their orders for bars are the best the bar mills are receiving.

Apart from these classes of demand, there is approximately a normal volume of demand for steel products from jobbers and from many classes of manufacturing consumers.

Where Demand Is Light

Where demand is light is among the railroads, the shipyards and investors generally who engage in large construction undertakings. There is practically no railroad demand at all. Even the 300,000 tons of rails it was reported several weeks ago the Railroad Administration would order, to round out its work for the year, have not appeared in the market. There would be no other buying of importance by the Railroad Administration, and the question is when the railroads will be placed in position to know what they will be justified in doing by way of improving their facilities, and what they will do when their position has been assured. While operating control of the roads is likely to be restored to the owners about Aug. 1, with the Government guarantee as to earnings running to the end of the year, the conditions under which the roads will operate in future, as to freight rates and the credit they can command, await action by Congress. The steel trade is of the impression that when railroad buying begins it will run rather to material needed for extensions of road and improvement of terminals than to freight cars.

Shipbuilding is at a greater rate than ever before, probably at between 600,000 and 700,000 tons deadweight per month, involving the consumption of 200,000 to 250,000 tons of steel, chiefly plates, per month, but the demands upon the mills are not in keeping, because stocks of steel at shipyards are being drawn upon.

Improvement in Construction Work

In construction work there is a steady improvement, as has been shown by the monthly returns of the Bridge Builders' and Structural Society and by various detached pieces of information as to contracts lately let or about to be let, but the pace even at this date is far below normal. It is true that much "building" activity is reported from practically all sections of the country, but this building runs largely to dwelling house construction and repair work generally. It is not, in general, the class of building that involves the consumption of much steel. As a matter of fact the activity is unfavorable to the steel industry rather than favorable, because with the supply of labor limited and also the supplies of some classes of material the facilities are pre-empted and construction work involving the use of large quantities of steel may be discouraged or postponed. The basic principle is that there is several years of work to be done, and the more pressing work will delay the less pressing. Thus dwelling houses will take precedence over bridges and skyscraper hotel and office buildings.

Steel Prices

The steel prices that became quotable March 21 are now firmly established. A considerable proportion of the steel bought in May and the fore part of June was at cut prices, though throughout the period the March 21 prices were regarded, generally speaking, as "the market." In the past few weeks this shading has been diminishing and it is now of very small proportions, except in plates, which present a relatively hopeless case, capacity being in excess of any easily conceivable demand. The condition has so changed that there is now no fear of any general decline in the market, while on the other hand, there are predictions in some quarters that advances in some lines will occur in the near future. It has now become generally known that the Steel Corporation some time ago adopted a definite policy, setting itself against any steel price advances, this year at least, and the question remaining is whether the independents in any line will be willing and able to engineer an advance of their own, thereby decreasing their prestige among buyers and forcing the Steel Corporation to choose between picking its customers or becoming badly oversold.

In view of the course the steel market has frequently pursued in the past, the maintenance of the general price level during May and June was remarkable. Many producers, including the Steel Corporation, refused absolutely to cut prices, being willing that mills disposed to cut should fill up. This forbearance was due in part to recognition of the fact that the business left on mill books at the conclusion of the war was very irregularly distributed, so that in the early months of the year some mills had been forced to operate at much lower rates than others. Thus it was only fair that mills should be allowed to buy their way into the market, while if the cuts had been met generally the sequel would simply have been additional cuts.

Pig Iron

The pig iron market has become well established. For several months consumers had been extremely desirous of reducing their stocks, and this policy was pursued to such length that many consumers found themselves with stocks far below normal, some with no stocks at all. A buying movement due partly to this situation and partly to increased consumptive requirements began the latter part of May. This movement appears now to have run its course, but it has left the furnaces that are in blast fairly well sold up, a few furnaces being sold up practically to the end of the year. The competition among districts has practically disappeared and prices in all districts are now on a fairly stable basis, with scarcely any prospect that prices will decline in the near future and a bare possibility that they will advance before the end of the year. An advance, however, is somewhat improbable so long as there are many idle furnaces, and should demand develop these furnaces would doubtless sell at the market, or a shade lower, to accumulate backlog business upon which to blow in.

The Chemical Market

New York, July 11, 1919.

Following the recent advance of *caustic soda* to $3.30 per cwt., the United States Alkali Export Association last week raised the quotation on light 59 per cent *soda ash* to $1.90.

Muriatic acid is gaining strength in the market although as yet no quotable change is announced. Dyestuff manufacturers are the principal buyers on the domestic end with Cuba still the main export source. Another acid which is feeling the general improvement is *sulphuric*, quantities of it being shipped to South America, whence emanates also a good inquiry for *caustic soda*.

Heavy sales of *potassium carbonate* are reported, most of it going for export. Stocks of *potassium prussiate*, yellow, are limited. The market is, therefore, advancing, now being 30-35c. per lb., an increase of 3c. *Sodium prussiate*, yellow, is in the same category. After a drop to 25c. per lb. last week, dearth of supply has brought the quotation up to the previous level of 35c.

Manufacturers are quoting *citric acid* at 98c. per lb., but find it difficult to deliver because of short stocks. Second hands are quoting $1.05 per lb.

Oils—With no oil available in quantities until August, business in linseed oil is practically at a standstill. Quotations on raw linseed oil in carlots, August delivery, range from $1.90 to $2.14 per gal. against $1.88-1.90 at last writing. Other vegetable oils are similarly situated, and the market is highly speculative. Thus far the signing of the peace terms has had no particular effect on trading, but as soon as Germany and Austria call for their badly needed fats further advances are to be expected.

Menhaden fish oils are reported scarce for spot but satisfactory for futures. The catches have been good, but the fish are lean and yield little oil. Soap, paint and varnish manufacturers are the heavy domestic users, while requests from Europe continue to be general. Winter pressed Menhaden is now quoted at $1.20-$1.25 per gal. against $1.10 two weeks ago.

COAL-TAR PRODUCTS—Among the crudes, benzol, solvent naphtha and toluol are the most active. Benzol continues in heavy request by rubber-tire manufacturers. Aniline oil is perhaps the strongest item among the intermediates. Nearly all manufacturers have their production for this month sold and few are offering any for sale during the remainder of the year. Japan is buying aniline oil and dimtheylaniline in quantities. Salicylic acid—which has been selling below the cost of production—has advanced five cents, to 25c. per lb. in carlots for the technical grade, owing to resale lots being off the market. It is rumored that the Government has on hand something like 20,000,000 lb. of phenol which will be turned over to two leading manufacturers for disposal at a figure officially fixed. Paratoluidine, H-acid and alpha-naphthylamine are having good sales, with ortho-toluidine and ortho-nitro-toluol beginning again to show signs of activity.

NAVAL STORES

After a drop from $1.10 per gal. to $1.02 during the past two weeks spirits of turpentine is again rising, at this writing having reached $1.05. The market in Savannah is also much firmer. The pale grades of rosins continue in active demand, with Holland the main customer. Owing to its increasing use in flotation processes, pine oil is in good demand. It is now quoted at 75c. per gal., a rise of 5c.

SHELLAC

The shellac market is still very much involved. Cables from Calcutta are from a week to ten days late and shed little light on the true situation. Dealers are merely endeavoring to supply regular customers and do not know when the situation will be relieved.

One dealer is quoting October-December delivery of TN at 90c., while another, on the same delivery, quotes 82c.; orange, superfine, 85c.; A.C. garnet, 72c.; and bleached, bone dry, 95c.

Chicago, July 9, 1919.

All heavy chemicals have either advanced a little or remained steady, coal-tar products show no fluctuation, vegetable oils are all up sharply and naval stores and flotation oils are in great demand at prices that seem very high.

HEAVY CHEMICALS—Caustic soda and soda ash, under the impetus of fairly heavy export orders to the Orient, are held strictly at market figures; caustic being quoted at 3c. to 3¼c. works for the solid and 4c. for the granulated, ash at 2c. Bleaching powder (*calcium hypochlorite*) is still quoted at 2c., with indications pointing to an advance.

Sulphuric acid is in heavy demand, sales being made at from $18 to $19 for 66-deg. Stocks of this staple are low, a combination of labor trouble and high cost of raw materials tending to curtail production. *Muriatic acid* is moving freely at $22; *nitric*, while not in such heavy demand, is quoted at 10½c. for 40-deg.

Potassium carbonate is expensive, because of dealers' stocks having been absorbed by export orders, the effect being a rise from the 13c. four weeks ago to 22c. to-day. *Sodium nitrate* is changing hands at $4.25 for crude, $5.60 for double refined, the demand being ordinary.

COAL-TAR PRODUCTS—Slight tendency of prices to stiffen is the only notable feature in this line, 90% *Benzol* being quoted at 25c. to 26c., 100% at one cent higher. *Solvent naphtha* is quoted at 24c. and commercial *xylol* at 26c. No changes of moment are noted among the intermediates, trading in the entire coal tar line being merely normal.

VEGETABLE OILS—Recent sharp advances have had a decidedly repressive effect on sales, users limiting their purchases strictly to current requirements. All sales are of spot stock for immediate delivery, and it is unlikely that contracts will be placed at current figures.

Soya bean oil is quoted for July-August delivery in Chicago at 18c., cocoanut oil, Manila, at 18¼c., sellers tanks. China wood oil brings 24c. in less than car lots, spots and futures being offered in cars at 21c. A definite shortage seems to have developed in corn oil, stocks going freely at 21c. and sellers tanks from the West at 19c. Cotton oil shows little activity at 25c. An advance in palm oil has been prevented by expected receipts from Europe, price being 17¼c.

FLOTATION OILS, NAVAL STORES—Naval stores are rising in price so rapidly that sales are being curtailed. Pure steam distilled pine oil is now held at 85c. in carloads, 90c. for less, for .933 test, an advance of 7c.—68c. to 75c., in car lots. Pine tar oil remains at 36c.

Turpentine continues to fluctuate between $1.05 and $1.10, the demands of consumers being sufficiently heavy at this figure to prevent any early decline in price. Stocks are reported to be very short.

St. Louis, July 10, 1919.

HEAVY CHEMICALS—An almost insatiate demand for *sulphuric acid* on the part of the fertilizer manufacturers and for *niter cake* on the part of the steel manufacturers is the outstanding development of the past two weeks. Producers report that while there are sufficient supplies of both these chemicals (and probably will be throughout the year) such large quantities are being contracted for and inquiries are so numerous that it is difficult to understand where the heavy tonnages sought for are going.

The only important price change reported since the last review is a 50c. per ton advance in 60% *sulphuric acid*, which is expected to result in an upward change in the price of other grades. An indication of the proportions the demand for 60% sulphuric is assuming may be had in the fact that one of the buyers in the local market has just closed a deal on the basis of an annual consumption of 15,000 tons as compared to a consumption of 4,000 tons last year, while another deal was consummated involving delivery of 100 tons monthly to a consumer who heretofore has required only 400 tons yearly. The 66%-grade is less active, the price still being $18 a ton. There is no change in the market for oleum.

Word is brought here by men in close touch with the fertilizer industry that because of the depletion of farm lands during the war, through the lack of commercial fertilizer, an unprecedented demand for fertilizers of all sorts now exists and is likely to continue for some time.

Muriatic Acid is not moving very rapidly, the price remaining at $22 a ton for 18%. *Sodium sulphate* (salt cake) has been selling heavily to glass manufacturers at $16.50 to $18, the former for heavy-tonnage contracts. There is more than a plentiful supply of salt cake, but from the manner in which the glass industry is preparing for the season to open on Aug. 15 it is expected present prices will remain firm.

Sodium bisulphate (niter cake): — Steel manufacturers who because of the scarcity of sulphuric acid during the war turned to niter cake for steel-pickling purposes will continue to use that chemical in place of sulphuric acid. Heavy sales of niter cake for this purpose are reported at $3.50 to $4 a ton. These prices are said to be representative of the market, the higher prices quoted in the last report representing special sales.

Nitric acid is the one item in the heavy chemical market in which a price decline is looked for. It is expected to occur on Aug. 1, due to the decline in the price of nitrate of soda. What little business is being done in this branch of the market is reported on the basis of 10c. to 10½c. per lb. for the 38° Baumé grade.

Zinc chloride is moving in heavy tonnage out of the local market to the tie-treating centers. As in the case of sulphuric acid, some consumers are trebling their normal requirements of zinc chloride. One transaction is reported involving a monthly shipment of 700,000 lb. to a plant which hitherto has been using only 140,000 lb. The price is firm at 4c. per lb. for the 50% solution, which is the only grade in which business on a large scale is being done here.

Zinc oxide was again quoted on formally by Mid-West producers, on July 1, but unlike previous announcements the list is subject to change without notice, though contracts are being written for delivery over the remainder of the year at the current prices, 8c. to 9c. per lb., according to lead sulphate content, in car lots; half a cent higher for smaller quantities.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JULY 11, 1919

Acetic anhydride	lb.	$0.52	—	$0.60
Acetone	lb.	.14	—	.15½
Acid, acetic, 28 per cent	cwt.	2.50	—	3.00
Acetic, 56 per cent	cwt.	5.50	—	6.00
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00	—	14.00
Boric, crystals	lb.	.13½	—	.14½
Boric, powder	lb.	.13½	—	.14½
Hydrochloric, tech. 20 deg	cwt.	1.40	—	3.00
Hydrofluoric, 52 deg	lb.	.10	—	.11
Lactic, 44 per cent. tech	lb.	.11	—	.12
Lactic, 22 per cent. tech	lb.	.05	—	.06
Molybdic, C. P	lb.	4.50	—	5.50
Nitric, 40 deg	lb.	.07	—	.08
Nitric, 42 deg	lb.	.07	—	.08
Oxalic, crystals	lb.	.23	—	.28
Phosphoric, Ortho, 50 per cent. solution	lb.	.07½	—	.10
Picric	lb.	.30	—	.40
Pyrogallic, resublimed	lb.	2.30	—	2.55
Sulphuric, 60 deg., tank cars	ton	11.00	—	13.00
Sulphuric, 60 deg., drums	ton	17.00	—	.....
Sulphuric, 60 deg., carboys	ton	20.00	—	.....
Sulphuric, 66 deg., tank cars	ton	16.00	—	18.00
Sulphuric, 66 deg., drums	ton	21.00	—	.....
Sulphuric, 66 deg., carboys	ton	25.00	—	.....
Sulphuric, fuming, 20 per cent.(oleum) tank cars	ton	20.00	—	22.00
Sulphuric, fuming, 20 per cent.(oleum) drums	ton	25.00	—	.....
Sulphuric, fuming, 20 per cent.(oleum) carboys	ton	30.00	—	.....
Tannic, U. S. P	lb.	1.30	—	1.40
Tannic (tech.)	lb.	.42	—	.60
Tartaric, crystals	lb.	.82	—	.85
Tungstic, per lb. of WO_3	lb.	1.20	—	1.40
Alcohol, Ethyl	gal.	4.00	—	4.85
Alcohol, Methyl	gal.	1.20	—	1.23
Alum, ammonia lump	lb.	.03½	—	.04½
Alum, potash lump	lb.	.08	—	.10
Alum, chrome lump	lb.	.15	—	.17
Aluminium sulphate, commercial	lb.	.01½	—	.03
Aluminium sulphate, iron free	lb.	.02½	—	.03
Aqua ammonia, 26 deg., drums	lb.	.06½	—	.08
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.30	—	.....
Ammonium carbonate, powder	lb.	.12½	—	.13½
Ammonium chloride, granular(white salammoniac)	lb.	.12½	—	.14
Ammonium chloride, granular(gray salammoniac)	lb.	.12	—	.14
Ammonium nitrate	lb.	.10	—	.17
Ammonium sulphate	lb.	.05	—	.06
Amyl acetate	gal.	3.75	—	3.80
Arsenic, oxide, lumps	lb.	.09	—	.09½
Arsenic, sulphide, powdered	lb.	.30	—	.32
Barium chloride	ton	75.00	—	85.00
Barium dioxide (peroxide)	lb.	.19	—	.24
Barium nitrate	lb.	.10	—	.12
Barium sulphate (precip.) (blanc fixe)	lb.	.01½	—	.03
Bleaching powder (see calcium hypochlorite)		.....	—	.....
Blue Vitriol (see copper sulphate)		.....	—	.....
Borax (see sodium borate)		.....	—	.....
Brimstone (see sulphur, roll)		.....	—	.....
Bromine	lb.	.40	—	.50
Calcium acetate	lb.	.02	—	.02½
Calcium carbide	lb.	.05½	—	.06
Calcium chloride, fused, lump	ton	19.00	—	25.00
Calcium chloride, granulated	lb.	.01½	—	.02
Calcium hypochlorite (bleaching powder)	cwt.	1.60	—	2.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate, monobasic	lb.	.22	—	.23
Calcium sulphate, precipitated	lb.	.10	—	.20
Carbon bisulphide	lb.	.05½	—	.06
Carbon tetrachloride, drums	lb.	.11	—	.14
Carbonyl chloride (phosgene)	lb.	.75	—	1.00
Caustic potash (see potassium hydroxide)		.....	—	.....
Caustic soda (see sodium hydroxide)		.....	—	.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05	—	.08
Cobalt oxide	lb.	1.60	—	1.65
Copperas (see iron sulphate)		.....	—	.....
Copper carbonate, green precipitate	lb.	.28	—	.31
Copper cyanide	lb.	.65	—	.70
Copper sulphate, crystals	lb.	.07	—	.08
Cream of tartar (see potassium bitartrate)		.....	—	.....
Epsom salt (see magnesium sulphate)		.....	—	.....
Formaldehyde, 40 per cent	lb.	.20	—	.21
Glauber's salt (see sodium sulphate)		.....	—	.....
Glycerine	lb.	.20	—	.23
Iodine, resublimed	lb.	4.25	—	4.30
Iron oxide, red	lb	.03	—	.18
Iron sulphate (copperas)	cwt.	1.00	—	1.75
Lead acetate, normal	lb.	.12½	—	.15
Lead arsenate (paste)	lb.	.15	—	.18
Lead nitrate, crystals	lb.	.85	—	.86½
Litharge	lb.	.09½	—	.10½
Lithium carbonate	lb.	1.50	—	.....
Magnesium carbonate, technical	lb.	.12	—	.14
Magnesium sulphate, U. S. P	100 lb.	2.70	—	3.00
Magnesium sulphate, commercial	100 lb.	1.75	—	2.60
Nickel salt, double	lb.	.13	—	.15
Nickel salt, single	lb.	.11½	—	.14
Phosgene (see carbonyl chloride)		.....	—	.....
Phosphorus, red	lb.	.55	—	.65
Phosphorus, yellow	lb.	.35	—	.39
Potassium bichromate	lb.	.25	—	.30
Potassium bitartrate (cream of Tartar)	lb.	.52½	—	.55
Potassium bromide, granular	lb.	.49	—	.50
Potassium carbonate, U. S. P	lb.	.60	—	.70
Potassium carbonate, crude	lb.	.11	—	.14
Potassium chlorate, crystals	lb.	.25	—	.31
Potassium cyanide, 98-99 per cent	lb.	Nominal		
Potassium hydroxide (caustic potash)	lb.	.32	—	.40
Potassium iodide	lb.	3.30	—	3.40
Potassium nitrate	lb.	.19	—	.22
Potassium permanganate	lb.	.55	—	.60
Potassium prussiate, red	lb.	.75	—	.85
Potassium prussiate, yellow	lb.	.30	—	.35
Potassium sulphate	ton	225.00	—	.....
Rochelle salts (see sodium potas. tartrate)		.....	—	.....
Salammoniac (see ammonium chloride)		.....	—	.....
Sal soda (see sodium carbonate)		.....	—	.....
Salt cake	ton	10.00	—	15.00
Silver cyanide	oz.	1.19	—	.....
Silver nitrate	oz.	.66½	—	.67½
Soda ash, light	100 lb.	$1.85	—	$2.00
Soda ash, dense	100 lb.	2.25	—	2.50
Sodium acetate	lb.	.06	—	.08
Sodium bicarbonate	100 lb.	2.25	—	2.50
Sodium bichromate	lb.	.07½	—	.09
Sodium bisulphate (nitre cake)	ton	3.00	—	10.00
Sodium bisulphite	lb.	.05	—	.07
Sodium borate (borax)	lb.	.07½	—	.08
Sodium carbonate (sal soda)	100 lb.	1.30	—	1.60
Sodium chlorate	lb.	.15	—	.18
Sodium cyanide	lb.	.30	—	.31
Sodium fluoride	lb.	.10	—	.15
Sodium hydroxide (caustic soda)	100 lb.	3.00	—	3.50
Sodium molybdate	lb.	2.50	—	.....
Sodium nitrate	100 lb.	3.00	—	3.25
Sodium nitrite	lb.	.10	—	.13
Sodium peroxide, powdered	lb.	.25	—	.30
Sodium phosphate, dibasic	lb.	.03½	—	.05
Sodium potassium tartrate (Rochelle salts)	lb.	.43	—	.45½
Sodium prussiate, yellow	lb.	.18	—	.20
Sodium silicate, solution (40 deg.)	lb.	.01½	—	.02½
Sodium silicate, solution (60 deg.)	lb.	.02½	—	.04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.15	—	1.50
Sodium sulphide, crystal, 60-62 per cent (conc)	lb.	.04½	—	.05
Sodium sulphite, crystals	lb.	.03½	—	.04
Strontium nitrate, crystals	lb.	.25	—	.28
Sulphur chloride	lb.	.05	—	.05½
Sulphur, crude	ton	32.00	—	35.00
Sulphur dioxide, liquid, cylinders	lb.	.10	—	.12
Sulphur (sublimed), flowers	100 lb.	3.05	—	3.60
Sulphur, roll (brimstone)	100 lb.	2.70	—	3.15
Tin bichloride (stannous)	lb.	.48	—	.50
Tin oxide	lb.	.60	—	.....
Zinc carbonate, precipitate	lb.	.18	—	.20
Zinc chloride, gran	lb.	.12½	—	.14
Zinc cyanide	lb.	.49	—	.50
Zinc dust	lb.	.09	—	.11
Zinc oxide, dry American	lb.	.09½	—	.11½
Zinc sulphate	lb.	.03½	—	.04

Coal Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00	—	$1.10
Alpha naphthol, refined	lb.	1.40	—	1.50
Alpha naphthylamine	lb.	.35	—	.50
Aniline oil, drums extra	lb.	.22	—	.24
Aniline salts	lb.	.28	—	.33
Anthracene, 80% in drums (100 lb.)	lb.	.90	—	1.00
Benzaldehyde (f.f.c.)	lb.	1.00	—	1.15
Benzidine, base	lb.	.95	—	1.15
Benzidine, sulphate	lb.	.90	—	1.10
Benzoic acid, U. S. P	lb.	1.00	—	1.10
Benzoate of soda, U. S. P	lb.	.95	—	1.10
Benzol, pure, water-white, in drums (100 lb.)	gal.	.24	—	.28
Benzol, 90%, in drums (100 lb.)	gal.	.23½	—	.27
Benzyl chloride, 95-97%, refined	lb.	.35	—	.40
Benzyl chloride, tech	lb.	.25	—	.35
Beta naphthol benzoate	lb.	3.75	—	4.50
Beta naphthol, sublimed	lb.	.75	—	.80
Beta naphthol, tech	lb.	.45	—	.55
Beta naphthylamine, sublimed	lb.	2.25	—	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.18	—	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23	—	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.85	—	.90
Cresylic acid, 95-97%, dark, in drums	gal.	.80	—	.85
Cresylic acid, 50%, first quality, drums	gal.	.60	—	.....
Dichlorbenzol	lb.	.07	—	.10
Diethylaniline	lb.	1.50	—	2.25
Dimethylaniline	lb.	.50	—	.57
Dinitrobenzol	lb.	.25	—	.37
Dinitroclorbenzol	lb.	.25	—	.28
Dinitronaphthaline	lb.	.45	—	.55
Dinitrophenol	lb.	.30	—	.32
Dinitrotoluol	lb.	.38	—	.45
Dip oil, 25% tar acids, car lots, in drums	gal.	.38	—	.46
Diphenylamine	lb.	.70	—	.75
H-acid	lb.	1.75	—	2.25
Metaphenylenediamine	lb.	1.20	—	1.80
Monochlorbenzol	lb.	.10	—	.14
Monoethylaniline	lb.	1.50	—	1.75
Naphthaline, crushed in bbls. (250 lb.)	lb.	.06	—	.08
Naphthaline, flake	lb.	.06½	—	.07½
Naphthaline, balls	lb.	.08½	—	.10
Naphthionic acid, crude	lb.	1.00	—	1.25
Nitrobenzol	lb.	.13	—	.15
Nitro-naphthaline	lb.	.35	—	.45
Nitro-toluol	lb.	.17	—	.20
Ortho-amidophenol	lb.	6.00	—	.....
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-nitro-phenol	lb.	1.25	—	.....
Ortho-toluidine	lb.	.30	—	.45
Ortho-nitro-toluol	lb.	.27	—	.40
Para-amidophenol, base	lb.	2.60	—	3.50
Para-amidophenol, H. Cl	lb.	2.75	—	3.25
Para-dichlor-benzol	lb.	.06	—	.10
Paranitraniline	lb.	1.00	—	1.25
Para-nitro-toluol	lb.	1.35	—	1.50
Paraphenylenediamine	lb.	3.50	—	4.00
Para toluidine	lb.	1.50	—	1.75
Phthalic anhydride	lb.	1.75	—	2.15
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.10	—	.13
Pyridin	gal.	2.50	—	.....
Resorcin, technical	lb.	3.50	—	3.75
Resorcin, pure	lb.	6.50	—	7.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.25	—	.30
Salicylic acid, U. S. P	lb.	.30	—	.35
Salol	lb.	.75	—	.80
Solvent naphtha, water white, in drums, 100 gal.	gal.	.20	—	.27
Solvent naptha, crude, heavy, in drums, 100 gal.	gal.	.18	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Tolidine	lb.	1.75	—	2.50
Toluidine, mixed	lb.	.45	—	.80
Toluol, in tank cars	gal.	.22	—	.24
Toluol, in drums	gal.	.23	—	.30
Xylidine, drums, 100 gal	lb.	.44	—	.46
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal	gal.	.23	—	.27
Xylol, commercial, in tank cars	gal.	.22	—	.....

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.43	—	$0.45
Beeswax, refined, yellow	lb.	.48	—	.55
Beeswax, white pure	lb.	.65	—	.68
Carnauba, No. 1	lb.	.90	—	.95
Carnauba, No. 2, regular	lb.	.75	—	.82
Carnauba, No. 3, North Country	lb.	.63	—	.65
Japan	lb.	.18½	—	.21
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06	—	.07½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.06	—	.06½
Paraffine waxes, refined, 118-120 m.p.	lb.	.07½	—	.08¼
Paraffine waxes, refined, 128-130 m.p.	lb.	.09	—	.10
Paraffine waxes, refined, 133-135 m.p.	lb.	.11	—	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	.12½	—	.....
Stearic acid, single pressed	lb.	.22	—	.23
Stearic acid, double pressed	lb.	.23	—	.25
Stearic acid, triple pressed	lb.	.24	—	.27

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$0.75	
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.45	
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.33	
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.58	
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.34	
Turpentine, crude, sp. gr., 0.900-0.970	gal.	.61	
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.24	
Hardwood oil, f.o.b. Mich., sp. gr., 1.06-1.08	gal.	.24	
Pinewood creosote, ref	gal.	.48	

Naval Stores

The following prices are f.o.b., New Nork, for carload lots.

Rosin B-D, bbl	280 lb.	$16.00	—	$16.25
Rosin E-I	280 lb.	16.35	—	16.75
Rosin K-N	280 lb.	17.90	—	19.50
Rosin W. G.-W. W	280 lb.	19.75	—	20.00
Wood rosin, bbl	280 lb.	15.50	—	.....
Spirits of turpentine	gal.	1.05	—	.....
Wood turpentine, steam dist	gal.	.96	—	.....
Wood turpentine, dest. dist	gal.	.93	—	.....
Pine tar pitch, bbl	200 lb.	8.00	—	8.25
Tar, kiln burned, bbl. (500 lb.)	bbl.	12.50	—	13.50
Retort tar, bbl	280 lb.	13.50	—	14.50
Rosin oil, first run	gal.	.81	—	.83½
Rosin oil, second run	gal.	.83	—	.85½
Rosin oil, third run	gal.	.85	—	1.02½
Rosin oil, fourth run	gal.	.88	—	1.05

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½	
70-72 deg., steel bbls. (85 lb.)	gal.	.31½	
68-70 deg., steel bbls. (85 lb.)	gal.	.30½	
V. M. and P. naphtha, steel bbls. (85 lb.)	gal	.23½	

Crude Rubber

Para—Upriver fine	lb.	$0.55	—	0.55½
Upriver coarse	lb.	.32	—	.33
Upriver caucho ball	lb.	.32½	—	.33
Plantation—First latex crepe	lb.	.39½	—	.40½
Ribbed smoked sheets	lb.	.38	—	.39
Brown crepe, thin, clean	lb.	.35	—	.36
Amber crepe, No. 1	lb.	.36	—	.37½

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls	lb.	$0.19	—	$0.21
Castor oil, AA, in bbls	lb.	.21	—	.23
China wood oil, in bbls	lb.	.21	—	.22½
Cocoanut oil, Ceylon grade, in bbls	lb.	.19½	—	.20
Cocoanut oil, Cochin grade, in bbls	lb.	.21	—	.22
Corn oil, crude, in bbls	lb.	.21	—	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.22	—	.23
Cottonseed oil, summer yellow	lb.	.27	—	.30
Cottonseed oil, winter yellow	lb.	.27	—	.28
Linseed oil, raw, car lots	gal.	1.90	—	2.10
Linseed oil, raw, tank cars	gal.	1.90	—	1.95
Linseed oil, boiled, car lots	gal.	1.90	—	2.10
Olive oil, commercial	gal.	2.25	—	2.50
Palm, Lagos	lb.	.17½	—	.18
Palm, bright red	lb.	.17	—	.18
Palm, Niger	lb.	.16	—	.17
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½	—	.24
Peanut oil, refined, in bbls	lb.	.28	—	.29
Rapeseed oil, refined in bbls	gal.	1.55	—	1.60
Rapeseed oil, blown, in bbls	gal.	1.60	—	1.65
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.19½	—	.20
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.16½	—	.17½

FISH

Winter pressed Menhaden	gal.	$1.20	—	1.25
Yellow bleached Menhaden	gal.	1.22	—	1.27
White bleached Menhaden	gal.	1.24	—	1.30
Blown Menhaden	gal.	1.26	—	1.35

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$25.00	—	$36.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.03½	—	.04½
Blanc fixe, pulp	ton	30.00	—	40.00
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	11.00	—	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	$30.00	—	$35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00	—	45.00
Fuller's earth, domestic, powdered	ton	30.00	—	40.00
Fuller's earth, imported, powdered	ton	.....	—	.....
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	.....
Shellac, TN	lb.	.....	—	.....
Shellac, D.C	lb.	.....	—	.....
Shellac, V. S. O	lb.	.....	—	.....
Shellac, Diamond I	lb.	.....	—	.....
Shellac, orange, fine	lb.	.....	—	.....
Shellac, orange, superfine	lb.	1.10	—	1.15
Shellac, A.C. garnet	lb.	.95	—	.....
Shellac, bleached, bone dry	lb.	1.35	—	.....
Shellac, bleached, fresh ground	lb.	1.05	—	.....
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	55.00	—	60.00

Refractories

Following prices are f. o. b. works:

Chrome brick	net ton	90–100 at Chester, Penn.
Chrome cement	net ton	45–50 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	35–45 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	30–35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50–55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90 at Chester, Penn.
Silica brick	net ton	41–45 at Mt. Union, Penn.

Ferro-alloys

All prices f. o. b. works.

Ferro-carbon-titanium, 15–18%, f.o.b. Niagara Falls, N. Y.	net ton	$220.00	—	.....
Ferro-chrome, per lb. of Cr. contained, 6–8% carbon	lb.	.32	—	$0.40
Ferro-chrome, per lb. of Cr. contained, 2–4% carbon	lb.	.70	—	.....
Ferro-manganese, 70-80% Mn	gross ton	100.00	—	125.00
Spiegeleisen, 16-20% Mn	gross ton	30.00	—	50.00
Ferro-molybdenum, per lb. of Mo	lb.	2.00	—	3.00
Ferro-silicon, 50%	gross ton	85.00	—	115.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10–15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.30	—	1.60
Ferro-uranium, 35-50%, of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40%, per lb. of contained V.	lb.	5.50	—	7.00

Resales and overstocks make above prices approximate.

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70		
Chrome ore, 48% and over	unit	.80	—	
Coke, foundry, f.o.b. mines	net ton	5.00	—	$5.50
Coke, furnace, f.o.b. mines	net ton	4.50	—	5.00
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00	—	16.50
Fluorspar, gravel, f.o.b. mines	net ton	20.00	—	25.00
Manganese ore, 45% Mn and over	unit	.60	—	.65
Manganese ore, chemical (MnO_2)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over per unit of WO_3	unit	9.00	—	11.50
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	8.00
Uranium oxide, 96%	lb.	.....	—	.....
Vanadium pentoxide, 99%	lb.	6.00	—	.....
Pyrites, foreign, lump	unit	.15	—	.....
Pyrites, foreign, fine	unit	.15	—	.....
Pyrites, domestic, fine	unit	.14	—	.....
Ilmenite, 50% TiO_2	net ton	30.00	—	.....
Rutile, 95% TiO_2	net ton	200.00	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00

Resales and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.30
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	15.00
Hollow building tile, At factory, Perth Amboy, N. J. 8x12x12	M.	194.40
Hollow building tile, At factory, Perth Amboy, N. J. 12x12x12	M.	291.60
Yellow pine, 3x4 to 8x8, 20-24 ft. long	M.	40.00
Yellow pine, 3x4 to 8x8, 20-24 ft. long at Chicago	M.	39.50
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis	M.	37.00
Roofings, tar felt (14 lb. per 100 sq.ft.)	ton	60.00
Roofings, tar pitch (in 400-lb. bbl.)	ton	21 00
Roofings, asphalt pitch	ton	34.00
Roofings, asphalt felt	ton	63 00
Roofings, slate-surfaced, per roll of 108 sq.ft.		2.00
Roofings, slate-finished shingles, 100 sq.ft.		5.00
Linseed oil, raw in barrels	gal.	2.15
Linseed oil, 5 gal. cans	gal.	2.28
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.16½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	.15½

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

CLAREMONT—The trustees of Pomona College have received a donation of $100,000 for the construction of a chemistry hall.

LINDSAY—The city voted $85,000 bonds for the construction of a gas system. Olmsted & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, engineers.

SACRAMENTO — The City Commissioners voted $1,800,000 bonds for the construction of a filtration plant for the municipal water system. T. Coulter, Commissioner of Public Works. Noted Jan. 15.

Connecticut

WATERBURY—The city will install a chemical laboratory in the basement of the 1-story garage which it plans to build. Esimated cost, $60,000. Cass Gilbert, 244 Madison Ave., New York City, N. Y., architect.

Florida

ARCHER—The Archer Cane Manufacturing Co., plans to build a large cane mill for making high grade syrup. A. D. Lindsay, president.

KEY WEST—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing oil burning equipment here, to the South Florida Contracting & Engineering Co., Eaton and Elizabeth Sts. Estimated cost, $5,800.

WEST PALM BEACH—The State Board of Health plans to install a modern filtration plant. Estimated cost, $75,000. Address G. W. Simmons, Jr.

Illinois

CHICAGO—Sears, Roebuck & Co., Arlington and Homan Aves., plans to build a 5-story paint factory on Kostner Ave. and Fillmore St. Estimated cost, $250,000. G. C. Nimmons & Co., 122 South Michigan Ave., architect.

GREAT LAKES—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for remodeling the sewage disposal plant here, to Hansen Bros. Co., 126 North Dearborn St., Chicago. Estimated cost, $17,481.

Indiana

INDIANAPOLIS — The Smith Dye Works, 531 Warsaw St., has awarded the contract for the construction of a 1-story, 30 x 65-ft. dry cleaning plant, to T. A. Moynahan, 1947 Broadway.

NEW ALBANY—The Calumet Fertilizer Co. has awarded the contract for the construction of a 48 x 65-ft. plant, to E. Embrey, New Albany. Estimated cost, $15,000. Noted May 15.

Iowa

STRAWBERRY POINT — The town plans to build one mile of sanitary sewers and a sewage disposal plant. W. F. Reinecke, mayor. H. R. Green, Union Block, Cedar Rapids, engineer.

Kansas

TREECE—The Early Bird Mining Co., Baxter Springs, will install an additional jig plant and is in the market for rolls, elevator pulleys, belting, shafting, etc. C. Bird, superintendent.

Kentucky

ASHLAND—The Board of Water Commissioners will receive bids until July 24 for the construction of a 2,000,000-gal. filtration plant and a centrifugal pumping plant of seven units. Alvord & Burdick, 4 South Dearborn St., Chicago, Ill., engineer. Noted May 15.

Louisiana

BATON ROUGE—The Aluminum Ore Co., East St. Louis, Ill., has acquired 227 acres near here and plans to build an aluminum ore refinery. Esimated cost, $1,000,000. C. E. Rudisill, c/o owner, engineer.

Maryland

CUMBERLAND—The American Cellulose Chemical Manufacturing Co., Ltd., plans to build an addition to its plant. Estimated cost, $1,000,000.

Massachusetts

PALMER—The Clinton-Wright Wire Co., Hammond St., Worcester, plans to build a 1-story steel plant here. Estimated cost, $100,000.

TURNERS FALLS—The Esleeck Manufacturing Co. plans to build a 5-story addition to its paper manufacturing plant here. Esimated cost, $75,000.

Michigan

DETROIT—The Detroit Seamless Tube Co., 841 West Jefferson Ave., has awarded the contract for two 1-story, 90 x 550-ft. additions to its plant, to be equipped with modern machinery for the manufacture of steel tubes, to A. A. Albrecht & Co., 1130 Penobscot Bldg. Estimated cost, $1,700,000.

Missouri

MACON—W. H. Martin, city clerk, has awarded the contract for the construction of a sewage disposal plant, to W. McClurken, 3807 Westminster Ave., St. Louis. Estimated cost, $16,000.

ST. LOUIS—The St. Louis Surfacer & Paint Co., Arlington and Terminal R.R., has awarded the contract for the construction of a 2-story, 28 x 47-ft. factory at 5438 Hazel St., to the W. R. Wilson Building Co., Odd Fellows Bldg. Estimated cost, $10,000.

WACO—The Union Metal Mines Co. plans to build a new concentrating mill at its mine in Waco Field, Kan., and is in the market for material for same. P. B. Bitler, general manager.

WEBB CITY—The Orange Mining Co. plans to enlarge its plant in every department and is in the market for crushers, rolls, hoists and compressor. H. H. Wallower, supt.

Montana

HELENA—The State Board of Examiners will soon award the contract for the construction of a laboratory for the Board of Health. Haire & Link, Power Bldg., architects. Noted April 1.

Nebraska

LINCOLN—The Lincoln Paint & Color Co., 811 M St., will rebuild its 2-story, 50 x 80-ft. paint factory recently destroyed by fire, entailing a loss of $25,000.

New Jersey

TRENTON—The city plans to build a sewage disposal plant. Estimated cost, $500,000. J. R. Fell, 134 North Montgomery St., engineer.

TRENTON—The Hamilton Rubber Co., Clinton and Mead Sts., has awarded the contract for the construction of a 3-story, 75 x 75-ft. plant, to Aitken & Bebbington, 115 South Stockton St. Estimated cost, $20,000.

TRENTON—The Luzeren Rubber Co., Muirheid Ave., has awarded the contract for the construction of a 2-story, 50 x 75-ft. addition to its rubber plant, to N. A. K. Bugbee Co., 204 East Hanover St. Estimated cost, $13,000.

TRENTON—The Stokes Rubber Co., Taylor St., has awarded the contract for the construction of a 1-story, 50 x 100-ft. addition to its plant, to N. A. K. Bugbee Co., 204 East Hanover St. Estimated cost, $8500.

New York

ALBANY—Dr. H. M. Biggs, Commissioner of Health, State Department of Health, Capitol, Albany, will receive bids until July 22 for installing apparatus and equipment in the laboratory building here, to include experimental extractions and distilling apparatus, water stills, autoclaves, etc. Estimated cost, $6000.

POUGHKEEPSIE—The State Hospital Commission, Capitol, Albany, has awarded the contract for altering and building additions to the water supply system at the Hudson River State Hospital, here, to the Baker-Dunbar-Allen Co., Stock Exchange Bldg., Philadelphia, Pa. Plans include installing additional filters, etc. Estimated cost, $52,000. Noted June 1.

North Carolina

CLINTON—The Sampson Oil & Fertilizer Co. plans to build a fertilizer factory. Estimated cost, $75,000. American Machine & Manufacturing Co., Greenville, S. C., architect.

Ohio

CLEVELAND—The Cleveland Electro Metals Co., 421 Guardian Bldg., has awarded the contract for the construction of a 2-story, 40 x 50-ft. addition to its factory at 2391 West 38th St., to the Drummond Miller Co., 422 Guardian Bldg. Estimated cost, $6000.

CLEVELAND—The Crucible Steel Castings Co., Canel Rd. and Champlain Ave., plans to build a 2-story, 125 x 300-ft. factory on Almira and Denison Aves. Estimated cost, $100,000.

CLEVELAND—The Ideal Tire & Rubber Co., East 17th St. and Euclid Ave., plans to build a 3-story, 100 x 200-ft. addition to its factory on Warren Rd. Estimated cost, $125,000.

CLEVELAND—The Vitreous Enameling Co., 6800 Grant Ave., has awarded the contract for the construction of a 1-story, 90 x 120-ft. factory on East 71st St. and Grant Ave., to W. Dunbar Co., 8201 Cedar Ave. Estimated cost, $35,000.

CLEVELAND—The National Copper & Smelting Co., Rose Bldg., plans to build a 3-story, 75 x 240-ft. factory on Babitt Rd. and Nickelplate Ry. Estimated cost, $25,000.

COLUMBUS—The Timkin Roller Bearing Co., Dueber Ave., Canton, has acquired a site and plans to build a 300 x 500-ft. branch plant here. Estimated cost, between $1,000,000 and $1,500,000. H. H. Timkin, president.

DAYTON—The Dayton Steel Co., Howell and Parker Sts., plans to build a factory for the manufacture of fabricated structural steel and bridges. Estimated cost, $35,000.

Pennsylvania

PHILADELPHIA—Firth & Foster, Emerald and Foster Sts., have awarded the contract for the construction of a 1-story, 64 x 68-ft. dye house, to F. A. Havens Co., 845 North 19th St. Estimated cost, $20,000.

PITTSBURGH—The Basic Mineral Co., 834 Columbus Ave., N. S., is having plans prepared by Leffler & Schubert, architects, North Side, for the construction of a 2-story, 75 x 75-ft. addition to its plant on Columbus Ave., for the manufacture of flux and deodorizer for melting metals. Plans include laboratory, mill and electric furnaces. Estimated cost, $25,000.

WILLIAMSPORT—The J. K. Mosser Tannery Co., a subsidiary of the Armour Leather Co., Newberry, will soon receive bids for the construction of a 6-story, 150 x 196 x 202-ft. tannery, on Arch St., here.

South Dakota

DEADWOOD—The Capital Gold Mining & Milling Co., 405 Brandies Theatre Bldg., Omaha, Neb., plans to build an air compressor plant, power line, etc., and is in the market for complete equipment. Estimated cost, $10,000. R. M. Harrop, general manager.

Tennessee

COLUMBIA—The Victor Chemical Co., Fisher Bldg., Chicago, Ill., plans to build a chemical plant near here. W. B. Brown, vice-president.

Washington

KELSO—The Union Oil Co. of California, Mills Bldg., San Francisco, has purchased a site and plans to build an oil distributing plant, including one 20,000-gal. distillate tank, one 20,000-gal. gasoline tank and one 20,000-gal. coal oil tank, at North Kelso. C. C. Ireland, representative.

SEATTLE—The West Coast Rubber Co., 4060 Occidental Ave., has awarded the contract for the construction of a 1-story, 112 x 153-ft. factory for the manufacture of rubber products, on 7th and Mercer Sts., to J. W. Johnson, 171 McGraw St. Estimated cost, $26,000.

SPOKANE—The International Steel Co. has purchased a site along the Chicago, Milwaukee & St. Paul R.R., and plans to build a steel rolling mill, to be equipped with electric furnaces. Estimated cost, $100,000. L. L. Bair, president.

Wisconsin

CARROLLVILLE—The United States Fertilizer Co., c/o U. S. Glue Co., has awarded the contract for the construction of a 2 and 3-story, 67 x 219 and 50 x 50-ft. fertilizing plant, to P. Riesen & Sons, 1018 Humboldt Ave., Milwaukee. Estimated cost, $100,000. Noted July 1.

Ontario

HAMILTON—The Quaker City Chemical Co., Philadelphia, Pa., plans to build a 3-story, 60 x 120-ft. chemical plant here. Estimated cost, $120,000. C. H. Mackay, Hamilton, Ont., engineer.

LONDON—C. S. Hyman, Richmond St., plans to build a new tannery. Estimated cost, $300,000. W. F. D. Jarvis, manager.

OWEN SOUND—The Dominion Oil Co. will receive bids until July 18 for the construction of a 3-story, 38 x 70-ft. plant for the manufacture of oils, greases and soaps. Estimated cost, $30,000.

PORT ARTHUR—The Carrick Pulp Mills plans to build an extension to its plant, in order to increase the capacity to 350 tons.

TORONTO — Baldwins of Swansea, Wales, England, plans to build steel rolling mills on Ashbridges Bay, here. Estimated cost, $3,000,000.

WINDSOR—The City Council plans to install filters at the waterworks. Estimated cost, $300,000. Address I. F. Smith.

Quebec

MONTREAL—The T. Davidson Manufacturing Co., 187 Delisle St., has awarded the contract for the construction of a 75 x 100-ft. factory for the manufacture of enamel wares, to A. F. Byers & Co., 340 University St. Estimated cost, $75,000.

Manufacturers' Catalogs

THE TRUMPBOUR-WHITEHEAD BRASS & COPPER CO., INC., has recently issued a booklet on monel metal. Of particular interest is the result of tests given this metal in the College of the City of New York in 1913, which are described.

THE ALLIS-CHALMERS MANUFACTURING Co., Milwaukee, Wis., has published illustrated catalog No. 107 descriptive of concentrating machinery and equipment. The catalog contains a brief treatise on principles of concentration, together with flow-sheets of typical mills in different parts of the country. An attractive booklet is also being distributed on the works and products of the company.

THE CELITE PRODUCTS CO., New York City, has just issued Bull. B-13 describing the use and application of Sil-O-Cel plastic cement for preventing heat losses and increasing the capacity of high-temperature equipment. Copies will be sent on request.

THE METAL & THERMIT CORP., New York, N. Y., has issued a folder entitled "How Thermit Healed My Broken Jaw," which illustrates the operations involved in making a thermit weld on the 13½-ton broken upper jaw of an alligator shear used by Jos. Joseph & Bros. Co., Modena, Pa. The break welded was 80 in. in length and varied from 4½ to 23 in. in thickness.

HUNGERFORD & TERRY, INC., calls attention to a general catalog of Hungerford filters which is now ready for distribution. This publication describes the full line.

THE BUFFALO FORGE CO., Buffalo, is distributing Section No. 400 on fans, blowers and exhausters, which are illustrated and described.

THE HOOKER ELECTROCHEMICAL CO., New York, has gotten out new folders on muriatic acid, bleach and liquid chlorine which the company will be glad to send to any one interested.

THE DORR CO., New York and Denver, has published Bull. No. 13 describing the Dorrco pump. This is a 16-page bulletin containing tables of dimensions, weights, capacities, etc., part lists, instruction for operating and illustrations.

THE JEFFREY MANUFACTURING CO., Columbus, Ohio, announces a new catalog No. 258 on standard apron conveyors. This catalog contains 75 pages, devoted to installations showing standard steel and wood apron conveyors in service in various industries, specifications, general dimensions and other important data.

THE IRVING IRON WORKS CO., Long Island City, has issued a booklet called "Irving Subway," which is the fireproof metallic ventilating flooring.

THE GENERAL CHEMICAL CO., New York, has gotten up an attractive book which is an extended report covering twenty years, from March 1, 1899, to March 1, 1919, and tells of its origin, organization facilities, field of activity and accomplishments.

THE CEMENT GUN CONSTRUCTION CO., Chicago, Ill., has just issued Gunite Book No. 6, entitled "We Do the Work," with illustrations of recent cement gun work.

THE WILLIAM P. POLLOCK CO., Youngstown, Ohio, has just received from the press Vol. No. 31, which contains a series of photographs of modern blast-furnaces.

THE BASTIAN-BLESSING CO., Chicago, Ill.: "Rego Welding and Cutting Apparatus" is the title of a new publication just issued by this company.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., calls attention to a new bulletin on the value of accurate measurements of gases and air in a gas plant, coke oven plant, steel plant or chemical plant.

THE AUSTIN CO. has just issued a new catalog of standard buildings which contains drawings, illustrations and specifications of each of the ten standard types, together with complete information concerning the scope of Austin Building Service.

THE COLORADO IRON WORKS CO., Denver, Colo., announces pamphlet No. 9-C on the improved impact screen for the wet or dry sizing of all kinds of materials.

THE W. S. ROCKWELL CO., New York, has published Bull. No. 42 on cost of heating of steel, which deals with fuel and labor conservation in a forge shop; the economizer forge is illustrated and described. In Bulletin No. 34 the application of the economizer principle of the economizer forge is fully illustrated and described. Copies will be sent upon request.

R. D. MUTTALL CO., Chicago, Ill., has gotten out a pamphlet on "Pedigreed Gears," which contains illustrations and descriptive matter.

THE MERRILL CO., San Francisco, Cal., calls attention to a new catalog on "The Nordstrom Lubricated Plug Valve."

THE GEO. C. VIDETTO MACHINERY CO., Pittsburgh, Pa., has issued leaflets on standard bucket elevators, self-traction trucks, self-feeding bucket loaders, etc.

THE GIFFORD-WOOD CO., Hudson, N. Y.: Bull. 42 on Field and Basin Saws illustrates and describes the many different types and what users say of their performance.

THE STANDARD SPIRAL PIPE WORKS, Chicago, Ill., is distributing Cat. No. 7, which deals with smooth bore reinforced spiral pipe, valves, cast-iron fittings, special steel fittings, hydraulic supplies, forged steel flanges and drop forgings.

THE WELLMAN-SEAVER-MORGAN CO., Cleveland, Ohio, has issued Bull. No. 17 on the Hughes Mechanical Gas Producer.

THE THOMPSON-STARRETT CO., New York, has just published two very interesting brochures. The first brochure, "Building and Industrial Construction," illustrates and describes the many types of buildings put up by this company, including the Municipal Building in New York, office buildings, hotels, exhibit buildings, museums, power houses, forging and machine plants and manufacturing plants of all kinds. The title of the second brochure is "Building for Victory," by Col. W. A. Starrett. This is a reprint of an article which appeared in *Scribner's* for November, 1918, which describes and illustrates the work of this company on the $50,000,000 powder plant at Nitro, West Virginia, which was built under the direction of D. C. Jacking, acting as director of explosives for the Secretary of War, and the Yaphank Cantonment, which was built in 100 days.

THE TIDE WATER OIL CO., New York, has issued a booklet on Fuel Oil, which is for use by engineers, plant managers and all those who are interested in fuel oil and its various applications for raising steam for power, for furnaces, gas making, etc. It contains formulæ for computing the relative cost of fuel vs. coal and comprehensive data on the instruments, tanks and other appliances necessary for its most efficient use.

Industrial Notes

THE ELECTRIC FURNACE CO., Alliance, Ohio, has just shipped one of its standard hose tilting type furnaces to the United States Navy Yard, at Washington, D. C. to be used in the Government brass foundry there. This furnace is provided with a motor-operated tilting mechanism and has a maximum hearth capacity of 2000 lb. The shell is 7 ft. in diameter and the furnace is rated at 105 kw. in electrical capacity.

MR. T. LINSEY CROSSLEY, who has been associated for a number of years with J. T. Donald & Co., consulting chemists, has taken over the Toronto office and laboratory of that firm at 43 Scott St., and will there carry on the business of consulting chemist and chemical engineer. Besides general consultation work, Mr. Crossley has specialized in municipal chemistry and the technology of pulp and paper manufacture.

THE AUSTIN CO., Cleveland, Ohio, announces the engagement of Mr. O. D. Conover as production and sales engineer on foundries and steel plants. Mr. Conover was formerly vice-president and chief engineer of the T. W. Price Engineering Co. of New York and production manager of the Ludlum Electric Furnace Corp. Mr. Conover's headquarters will be at the Cleveland office of the Austin Co.

The first heat of steel from the Greaves-Etchells electric furnace at the League Island Navy Yard, Philadelphia, was made July 1. The furnace was recently installed in the new foundry by the ELECTRIC FURNACE CONSTRUCTION CO., Philadelphia, Pa. The Electric Furnace Construction Co. also announces that it has received an order for an electric furnace for the manufacture of ferro-alloys for Spain, from the Sociedad Española de Construccion Naval, the advisory committee of which consists of the firms of Sir W. G. Armstrong Witworth & Co., Vickers, Ltd., and John Brown & Co. This is the first furnace of its kind to be erected in Spain for converting that country's natural ores into ferro-alloys.

THE J. P. DEVINE CO., Buffalo, N. Y., has recently completed or has in process of construction several new additions to its plant for the manufacture of chemical apparatus. One of the additions, 30 ft. x 100 ft., is housing the department for the assembling of vacuum pumps; another, 90 ft. x 100 ft., now in course of construction, will enlarge the general assembling department. Construction is proceeding on a new foundry, 90 ft. x 225 ft., which will give greatly increased facilities for making large castings. Employment will be provided for 200 additional men.

The *C-H Messenger*, the shop newspaper of the CUTLER-HAMMER MFG. CO., contains in a recent issue photographs and names of many of the company's men who served in the recent war. The list is incomplete, but there are nearly 300 names on this Roll of Honor.

THE MORGAN CONSTRUCTION CO. announces that the Cambria Steel Co. has installed 51 Morgan gas producers at the Franklin furnaces at the Weirton Steel Co. of Weirton, W. Va., and is building an entirely new open-hearth and blooming mill plant containing 27 Morgan producers. The same equipment has been purchased by four British steel plants this year.

THE GEORGE J. HAGAN CO., Pittsburgh, Pa., has closed a contract with a French company for the purchase of foreign rights on the Hagan Co.'s patented devices for sheet, tin-mill and job-mill furnaces. The contract was closed for a large cash consideration and gives the French company rights in all European countries. The Hagan Co. reports important sales of its patented furnaces to the Eastern Rolling Mill Co., Baltimore, the American Sheet & Tin-Plate Co., Gary; the LaBelle Iron Works, Canton Sheet Steel Co., Otis Steel Co., and the Newport Rolling Mill Co.

MESSRS. H. D. STALEY and G. A. FISHER, doing business under the name of the Western Steel & Engineering Co., 35 Montgomery St., San Francisco, have been appointed California representatives for the United Filters Corp.

THE STEPHENS-ADAMSON MFG. CO., Aurora, Ill., announces its new representation in the San Francisco district. The firm of Bannon, Bodinson, MacIntyre, Inc., 317 Market Street, San Francisco, will have charge of the engineering sales work in this territory.

THE NEW JERSEY ZINC CO. of New York has just established warehouses in San Francisco and Los Angeles from which its products will hereafter be distributed to its trade on the Pacific Coast.

THE NASH ENGINEERING CO., South Norwalk, Conn., announces a change in the trade name of its pumps from Nash hydroturbine to "Hytor."

THE STANDARD CAR CONSTRUCTION CO. and the STANDARD CAR EQUIPMENT CO. are now merged under the name of the Standard Tank Car Co., with head offices and works at Sharon, Pa.

THE WESTINGHOUSE CHURCH KERR & CO., INC., announces the election of Mr. Arthur K. Wood, formerly president of the Franklin Trust Co., as vice-president and treasurer.

THE WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburgh, Pa., announces the appointment of Mr. C. S. Coler as manager of the educational department of the Westinghouse Co., and president of the Casino Technical Night School, an institution supported by the Westinghouse Co., to promote the education of its employees who wish to study in the evening. Mr. Coler is also president of the local chapter of the National Association of Corporation Schools, a member of the Society for the Promotion of Engineering Education and chairman of the technical sections of the Westinghouse Club.

THE JOHN JOHNSON CO. of Brooklyn, N. Y., announces the appointment of Mr. James N. Vermilya as sales engineer. Mr. Vermilya will devote his attention as chemical engineer principally to filtration and mixing problems encountered in the chemical industry.

THE EDISON STORAGE BATTERY CO. announces the election of Mr. Charles E. Sholes as vice-president, director and general sales manager, succeeding Mr. Harrison G. Thompson. Mr. Sholes was formerly with the Grasselli Chemical Co., and during the war was commissioned a Major in Ordnance. He is chairman of the New York Section of the Society of Chemical Industry and a member of many other scientific societies.

THE AMERICAN STEAM CONVEYOR CORP. announces the appointment of Samuel F. Joor as sales engineer. Mr. Joor was formerly Western manager and sales engineer of the Jeffrey Manufacturing Co.

THE BAILEY METER CO. announces the removal of its main office and works to East 46th Street, Euclid, Cleveland, Ohio. The Boston office will be retained to render service in the New England and Atlantic coast states. This company also announces the appointment of Mr. E. A. Hitchcock, formerly professor of experimental engineering at Ohio State University, as vice-president, supervising the training of technical graduates for the service and sales department.

THE AMERICAN-LAFRANCE FIRE ENGINE CO., INC., of Elmira, N. Y., is employing for the protection of chemical fire apparatus an acid and alkali resisting paint which was developed for the company at the laboratory of Arthur D. Little, Inc., of Cambridge, Mass.

Some time ago *The Little Journal* published an account of the Eckert process of increasing the growth of sugar cane and preventing the growth of weeds in Hawaii by covering rows of young cane with yard-wide sheets of a specially prepared paper. The cane shoots, being stiff and sharp, perforate the paper, while the weeds curl up and die. At the experimental paper mill of ARTHUR D. LITTLE, INC., of Cambridge, Mass., a method was developed to make this special paper from bagasse, or cane from which the sugar has been extracted. Later, the same organization built a mill in Hawaii for the Olaa Sugar Co., of which the patentee, Mr. C. F. Eckert, is manager, and it is now in successful operation.

HAMILTON & HANSELL, INC., New York, announces the sale of a Rennerfelt furnace of 300-lb. capacity and 60 k.v.a. to the General Chemical Co., to be installed at Laurel Hill, Long Island.

THE BLAW-KNOX CO. has sold its plant at Wheatland, Pa., in accordance with its program to concentrate all of its manufacturing at Hoboken, Pa. About one-half of the new plant at Hoboken has been completed and the entire addition will be finished within a few weeks. The combined plants at Hoboken will afford about 30 per cent more floor space than was available in the two separate plants. In addition to these activities the company is completing a welding plant and will specialize in this line on steel mill and chemical plant requirements.

Mr. Mark R. Lamb, who has been engaged in purchasing for export, has secured control of the NEW YORK STEEL EXCHANGE, INC., with which he has combined his own export business. This merger of specialized mining and heavy machinery export business with the export line of iron and steel products will give increased facilities for handling new European business. The new organization will operate under the corporate name of the New York Steel Exchange, Inc., and will be under the immediate management of Mr. Lamb.

THE YORK STEEL CORP., York, Pa., which was recently organized, has purchased an 80-acre tract of land just outside of the city on which it will erect a plant for the manufacturing of sheet steel, to be supplied to the York Corrugating Co.

Mr. E. E. Maher announces the formation of the MAHER ENGINEERING CO., with offices in the Michigan Boulevard Bldg., Chicago, Ill., to handle the sale and installation of Erie Engine Works high speed engines, the Sims Co. feed water heaters, Dayton-Dowd Co. centrifugal pumps, Wagener Steam Pump Co. pumps and Pratt Engineering & Machine Co. fertilizer and sulphuric acid machinery.

THE CHICAGO PNEUMATIC TOOL CO. announces the appointment of Mr. L. C. Sprague, formerly district manager of sales at New York, as manager of Western railroad sales, with headquarters in the Fisher Bldg., Chicago, and Mr. H. G. Barbee as manager of Eastern railroad sales, with headquarters at 52 Vanderbilt Ave., New York City. Mr. Nelson B. Gatch, formerly district manager of sales at Chicago, has been appointed district manager of sales at New York, succeeding Mr. Sprague.

THE MIDWEST ENGINE CO., Indianapolis, Ind., manufacturer of pumping equipment, announces the opening of four new offices, as follows: Florida Life Bldg., Jacksonville, Fla., in charge of D. J. Carrison; 303 Caples Bldg., El Paso, Tex., in charge of Chester B. Loomis; 111 Broadway, New York City, in charge of B. H. Downing; 617 Maison Blanche Bldg., New Orleans, La., in charge of J. R. Lowe.

Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold a meeting in Chicago, Sept. 24.

THE AMERICAN CHEMICAL SOCIETY will hold its Fall meeting in Philadelphia, Pa., Sept. 2-6 inclusive.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its Fall meeting in Chicago, Sept. 23-25 inclusive.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its 1919 convention in Philadelphia, Sept. 29 to Oct. 4.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its Fall meeting in Chicago, Ill., Sept. 22-27.

THE AMERICAN STEEL TREATERS' SOCIETY will hold its first annual convention in Chicago, Ill., Sept. 22-27.

THE FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in Chicago, Ill., Sept. 22-27 inclusive.

THE INSTITUTE OF METALS DIVISION of the A. I. M. E. will hold its next meeting in Philadelphia, Pa., Sept. 29 to Oct. 4.

THE INSTITUTE OF METALS will hold its Autumn meeting in Sheffield, England, Sept. 24-25.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its Fall meeting in Chicago from Sept. 24 to 27.

New Publications

NEW BUREAU OF STANDARDS PUBLICATIONS: Circ. No. 82. Recommended specification for linseed oil—raw, refined and boiled; Scientific Paper No. 336. A simplification of the inverse-rate method for thermal analysis. By P. D. Merica; No. 125. Viscosity of gasoline. By Winslow H. Herschel, issued May 5, 1919; No. 128. Effect of solar radiation upon balloons. By Junius Davis Edwards and Maurice Blaine Long, issued June 13, 1919.

THE UNITED STATES TARIFF COMMISSION: Report on dyes and related coal-tar chemicals, 1918.

THE DEPARTMENT OF COMMERCE: International Price Comparisons. By Wesley C. Mitchell, assisted by Margaret L. Goldsmith and Florence K. Middaugh.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 165. Bibliography of petroleum and allied substances in 1916. By E. H. Burroughs; Bull. 168. Recovery of zinc from low-grade and complex ores. By Dorsey A. Lyon and Oliver C. Ralston; Bull. 177. The decline and ultimate production of oil wells, with notes on the valuation of oil properties. By Carl H. Beal; Bull. 179. Abstracts of current decisions on mines and mining, reported from Sept. to Dec. 1918. By J. W. Thompson; Tech. Paper 222. Method of administering leases of iron-ore deposits belonging to the State of Minnesota. By J. R. Finlay; Tech. Paper 223. Cost keeping for small metal mines. By J. C. Pickering; Tech. Paper 224. Metal-mine accidents in the United States during the calendar year 1917 with supplemental labor and accident tables for the years 1911 to 1917, inclusive. Compiled by Albert H. Fay; Minerals Investigation Series No. 15. Concentration of native sulphur ores by flotation. By James M. Hyde; No. 16. Uses of manganese other than for steel making. By W. C. Phalen; the fifteenth biennial report of the Bureau of Mines of the States of Colorado 1917-1918; TNT as a blasting explosive. By Charles E. Munroe and Spencer P. Howell, dated June, 1919; War gas investigations. By Van H. Manning, which gives the scope of the war gas investigations and the names of the personnel connected with each division.

Stocks and Bonds

Closing Bid and Asked Quotations July 14, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch.....	109½	109¾	Mat.Al.Wk .	31	40
do.pf.....	98	100	Ten. C. & C.	15½	15¾
Barrett Co...	138	140	Un. Dyewood.	63	70
do.pf.....	114	116½	do. pf.....	97	97½
Gen.Chem.....	185	195	Va.-Car. Ch.	88¼	88¾
do.pf.....	102½	109	do. pf.....	115	116
Int.Ag.Ch....	34	34½			
do. pf. ...	90½	90¾			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	98¾	100
Am. Ag. Ch., cv. db. 5s, '24.....	108½	113
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32....	84	84½
Va.-Car. Ch., 1 mtg. 5s, '23.....	96¾	96½
Va.-Car. Ch., cv. db. 6s, '24.....	102½	103¼

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	92	93	P-A Pet & Tr	104½	105
Cal. Pet.....	38½	38¾	do. pf.....	...	...
do. pf.....	80	81	Pierce Oil.....	...	...
Col. G. & E..	63	63½	Royal Dutch..	114½	115¼
Mex. Pet.....	191	191½	Sinclair O & R.	64½	64¾
do. pf.	107½	110	Texas Co....	272½	273
Ohio Cit. Gas	59½	60	Tex. Pac. Ld Tr.....	400	500
do. pf.....					
Ohio Fuel S...	49	52½	Tidewater Oil.	243	245
Okla. P. & R..	11	11¼			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	88	90
Col. G. & El., std. 1 5s, '27.....	88	..
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	140	...
Pierce Oil, cv. db. 6s, '20.....	115	130
Pierce Oil, cv. 5% Notes, '24.....	106	106½
Sin. O. & R. 1 In.7s, '20, with stk. war.....	...	150
Sin. O. & R. 1 In. 7s, '20 without stk. war..	99½	99¾
Texas Co., db. 6s, '31.....	102½	103
Union Oil of Cal. 1 5s, '31.....	93¾	94½
United Fuel Gas 1 mtg. 6s, ser.A, '36.....	94½	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F.....	44½	45	Pitts. Ste. pf..	96	97
Beth. Steel...	94½	95	Rep. Iron & Steel.....	97½	98
do. class B.	95½	96	do. pf.....	104	104½
do. pf., 8%....	...	...	Sloss Sheff. I. & S.....	72	73
do. pf., 7%....	111½	112	do. pf.....	94½	98
Central Fdry.	34	34½	Superior Steel.	46½	47
do. pf.....	65½	67	do. 1 pf...	104	110
Col. F. & I...	55½	55¾	Trans. & W. Steel.....	55	56
do. pf.....	105	125	Un. Alloy St..	54½	55
Cruc. Steel..	135½	139½	U.S.C.I.P.&F.	34½	35
do. pf.....	103	105	do. pf.....	70	73
Great No. Ore	51½	51¾	U. S. Steel....	111½	111¾
Gulf Sta. Steel	69½	70	do. pf.....	116½	116¾
do. 1 pf....	94	98	Va. Coal,I&C.	67½	69
Lack. Steel...	86½	87			
Mid.St.& Ord.	59½	59½			
Nova Scotia Steel.....	83	84			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	96½	96½
Beth. Steel, 1 In. ref. 5s, Ser. A, '42.....	92	92½
Beth. Steel, P. M. & I. S. F. 5s, '36.....	88	88½
Buff. & Susq Iron, 1 S. F. 5s, '32.....	92	96
Buff & Susq. Iron, deb. 5s, '32.....	...	...
Cent. Found. 1 mtg. S. F. 6s, '21.....	80	83
Col. F. & I., gn. S. F. 5s, '43.....	90	92
Ill. Steel, db 4½s, '40.....	85½	86
Ind. Steel, 1 mtg. gtd. 5s, '52.....	96	96½
Lack. Steel, 1 5s, '23.....	97	98
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	93	95
Mid. St. & Ord., clt. cv. S. F. 5s, '36.....	89½	90½
Nat. Tube, 1 mtg. gtd. 5s, '52.....	98¼	99
Rep. I. & S., S. F. mtg. 5s, '40.....	94½	95
Tenn. C. & I. R.R. 'gn. 5s, '51.....	93	94
U. S. Steel, S. F. 5s, 63.....	100½	101
Va. C., I. & C., 1 5s, '49.....	86	88½